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Through Karnataka Public Procurement Portal

KARNATAKA WATER SECURITY AND DISASTER RESILIENCE PROGRAM (KWSDRP)

TENDER FOR THE WORK OF

DESIGN, ENGINEERING, CONSTRUCTION AND COMMISSIONING OF WASTEWATER TREATMENT PLANTS WITH TERTIARY TREATMENT FACILITY, SOLAR PANELS ALONG WITH OPERATION & MAINTENANCE THEREOF FOR TEN YEARS [WORKS - A]

AND

PROCUREMENT AND CONSTRUCTION OF RISING MAIN, MAIN SEWERS AND LATERALS INCLUDING MACHINE HOLES AND LIFT SEWAGE PUMPING STATIONS [WORKS – B]

HYBRID MODE FOR MAHADEVAPURA ZONE IN 110 VILLAGE AREAS (Phase II) UNDER KARNATAKA WATER SECURITY AND DISASTER RESILIENCE PROGRAM (KWSDRP) – (Contract Package No. BWSSB CE-P/KWSDRP/WBS-V)

VOLUME 2 of 4

(TECHNICAL SPECIFICATIONS AND TECHNICAL SCHEDULES)

APRIL – 2025

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PART 1

PROJECT DETAILS

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PART 1

PROJECT DETAIL

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PART-1

PROJECT DETAILS

1.1 Background to the Project

Bangalore is experiencing unprecedented rapid growth in the field of Industrial, Commercial, and Institutional sectors. This phenomenal growth has led to unplanned urban development surrounding Bangalore, resulting in an increase in population and construction activities. Furthermore, with the inclusion of 110 Peripheral villages in BBMP, the population of Bangalore city has increased by 50% over the last decade, i.e., from 8.5 million (2011) to 12.765 million (2021). The 110 Villages located in the periphery of the Bruhat Bangalore Mahanagar Palike, with an area of about 225 sq. km, are experiencing rapid growth, demanding basic infrastructure. This sudden growth in population in the peripheral area is posing tremendous pressure on basic infrastructure, especially on the Water Supply and the Underground Sewerage system. This has also resulted in urban flooding and the entry of sewage into lakes, polluting the water bodies situated in 110 villages.

To facilitate the UGD facilities (laterals) to 110 villages located in the periphery of BBMP, covering an area of approximately 225 sq. km, BWSSB had undertaken and completed the work of providing a UGD network (laterals) with financial assistance from the Government of Karnataka. Furthermore, to convey and treat the sewage from these laterals under the JICA-funded Cauvery stage V project, construction of 14 No. STPs of various capacities totaling 124 MLD are taken up along with laying of sub-mains and trunk sewers. Accordingly, works were undertaken in the R.R. Nagar, Dasarahalli, Byatarayanapura, Mahadevapura, and Bommanahalli zones.

Despite providing UGD network and sewage treatment system to 110 villages, due to exponential growth between planning and execution of projects, fund constraints, and the addition of new areas require additional infrastructure to service the newly added areas.

Thus, to provide the UGD facilities in a comprehensive manner, BWSSB has proposed the following works under the Karnataka Water Security and Disaster Resilience Program (KWSDRP) through the Government of Karnataka with financial assistance from the World Bank. Accordingly, the Government of Karnataka cabinet has accorded administrative approval for the implementation of the project on 05.03.2025. This Project is under performance for Results (P for R) considering various initiatives taken up by the BWSSB in the field of Sewerage System.

The entire project area is divided as shown below based on the topography and natural drainage pattern of the drainage zone of the 110 villages:

Contract Package	Catchment	Drainage Zone
WBS-1	V Valley	RR Nagar & Dasarahalli
WBS-2a	Hebbal Valley	Byatarayanapura- WwTP
WBS-2b	Hebbal Valley	Byatarayanapura- UGD Network
WBS-3	K & C Valley	Bommanahalli
WBS-4	K & C Valley	Bommanahalli
WBS-5	K & C Valley	Mahadevapura

1.2 Works Details for Contract Package WBS 5

Works-A **:** Design, Engineering, Construction and Commissioning of Wastewater treatment plants along with Operation & Maintenance thereof for 10 years.

Works-B **:** Procurement & Construction of Main sewers & laterals including Machine holes and Lift Sewage Pumping Stations and Pumping Mains.

1.3 Components List for Works-A

Proposed Wastewater Treatment Plant is in the Mahadevapura drainage zone lies in the K & C Valley Catchment area. Following table shows the designed average flow capacity of Proposed Wastewater Treatment Plant.

Sl. No.	Zone	WwTP Location	Average Flows (MLD)
1	Mahadevapura	Channasandra	20 MLD

*Proposed Wastewater Treatment Plant is for the projected population for the year 2039. The proposed treatment process is technology-open, but limited to the following:

EA Process, or IFAS Process, or MBBR Process, or SBR Process, incorporating biological nitrification, de-nitrification, and phosphorus removal. All these process options shall be followed by Disc filters, Chlorine Disinfection and Mechanical Sludge Dewatering. And Industrial Reuse Facilities with GLR and Pump House as defined.

1.4 Components List for Works-B

The Proposed Sewer network system and Lifting Pumping Stations (LPS) are in the catchment area of K & C Valley & in the drainage zone of Mahadevapura. Following table shows the details of the LPSs and these LPS are proposed for the year 2054 projected flows:

S.No.	Zone	LPS Name	Average Flows (MLD)
1	Mahadevapura	Halasahalli	0.9 MLD

The following table shows the details of the pumping mains from LPSs and these pumping mains are proposed for the year 2054 projected flows:

S.No	Pumping Main		Diameter (mm)	Length (m)
	From	To		
1	Halasahalli	To Ridge Machine hole	150	1000

Notes:

1. *Length may be subject to adjustment during Contract based on topographic survey and other factors.*

Following table shows the details of the gravity sewer mains with machine holes and these sewer mains are proposed for the year 2054 projected flows.

S. No.	Zone Name	Diameter (mm)		Total Length of Sewer Network (m)	No. of Machine holes
		250 (DWC) (m)	300 (DWC) (m)		
1	Mahadevapura	40000	2000	42000	1320
Total		40000	2000	42000	**1320**

Notes:

1) *Length and number of Machine holes may be subject to adjustment during implementation of Contract based on confirmatory topographic survey and other factors.*

1.5 Scope of Work for Works-A

The Scope of Work under this contract includes but is not limited to the following in relation to the design, build (construction) and operation and maintenance of the Works, which are to be implemented under Works-A:

- Topographical survey, geotechnical investigation, and any other investigation complete.
- Preparation of process and hydraulic designs with layout, process flow diagram, piping and instrumentation diagram, mass balance and hydraulic flow diagram of the complete WwTP including Terminal Sewage Pumping Station (TSPS) as stipulated in scope.
- Detailed sizing, design, and engineering, of all treatment units, buildings, structures, and equipment (including all civil, mechanical, electrical, architectural, instrumentation, control, automation, and SCADA components).
- Preparation of GA Drawings, Unit Process/Equipment/Facility/Building layouts, etc. complete.
- Design, construction, testing and commissioning of all civil structures, building works, bypass lines and other pipelines complete.
- Submission of detailed engineering designs, drawings, calculations, and data sheets as per requirements of Tender Document.
- All preparatory work including clearing, levelling of site, site grading, formation of Finished Ground Level (FGL), construction of internal roads, all around compound wall etc., excavation, dewatering as required and disposal of all surplus earth to a suitable location as specified/directed by Engineer.
- All existing facilities that are to be demolished to accommodate WwTP/TSPS shall be properly de-commissioned, removed, stacked and appropriately disposed of by the Contractor after getting the approval on its Salvage value as directed by Engineer.
- Demolishing shall be carried out in accordance with all applicable laws, regulations, and standards. Items, components, or materials, whether buried, exposed, submerged, or otherwise, shall not be abandoned or left on site unless explicitly specified.
- Design, construction, and commissioning of all pipelines, flow meters, channels, outfall structure for the disposal of plant effluent from chlorine contact tank to nearby water body at each site complete.
- Procurement, supply, installation, erection, testing and commissioning of all mechanical, electrical, instrumentation, PLC/SCADA system complete.
- Design and construction of complete plant water supply for potable and non-potable purpose including plant sewerage system.

- Design and construction, of approach road, all internal plant roads & internal storm water drains, curbs, pavements, parking spaces, compound wall, retaining walls, culverts, nalla diversion works complete.
- Interconnections with Works-B or existing sewer lines and other works as required complete.
- Plant testing, commissioning, stabilization, demonstration of performance guarantee.
- Complete plantation and landscaping works to give pleasant environment of build out campus.
- Receiving Raw Inlet Sewage at site and discharge of Plant Effluent to nearby water body as specified in Employer's Requirements.
- Monitoring of Online Real time Multi parameter systems at Inlet & outlet of WwTP, auto sampler and laboratory equipment's complete.
- PLC based SCADA system for fully automatic & safe operation of each WwTP and TSPS.
- Wireless Communication System for remote monitoring of WwTP, TSPS from Central SCADA Station (MIS-2) at Shimsha Bhavan as well as wireless communication between PLC & WwTP SCADA.
- Auxiliary systems like CCTV monitoring of each WwTP and TSPS.
- Preparation and submission of As-Built drawings for all civil, mechanical, electrical, Instrumentation, SCADA works complete.
- Handing over the facilities.
- Submission of Operation and Maintenance Manuals.
- Ten (10) years Operation and Maintenance for all WwTP and TSPS after successful passing of the Tests on Completion of Design-Build and Issue of the Commissioning Certificate as per the Conditions of Contract given in Volume 1 of the Tender Document.
- Transportation and disposal of screening, grit and dewatered sludge cake as specified in Employer's Requirements. BWSSB will provide the land for disposal of sludge in the vicinity 15 to 20 kms radius of each WwTP(s).
- Providing training services to Employer's personnel including O&M staff.

Notes:

- *Contractor to submit Unit Process / Equipment / Facility / Building wise Construction Approach and Methodology, prior to start of each/any type of constructional activity at site for necessary approval from Competent Authority.*
- *It shall be mandatory for Contractor to take prior approval on EMP and EMoP document based on the requirements as specified in the Tender Document.*
- *Contractor shall coordinate with KSPCB, BBMP, BESCOM, LDA and any other Departments and obtain all applicable consents certificates necessary for the design, build (construction) and operation & maintenance of the Works as described in the contract.*
- *Contractor shall provide a temporary shed and/or building of area minimum 350m2 on the Site/near to site for use by the Contractor for storage of Plant/machinery prior to inspection and/or dispatch from the manufacturer location and shall be subject to the approval of the Engineer.*
- *Contractor is responsible for liaisoning with external agencies like BBMP/BESCOM/Traffic Police etc.,*
- *Preliminary Data provided in the Tender Document is only for Guidance Purpose same required to be verified by the contractor upon visiting the site.*
- *Contractor to ensure efficient, effective and safe treatment of waste water.*

- *Wastewater plant to be designed to meet or exceed local and national regulations, as well as specific treatment goals (i.e. nutrient removal).*
- *Plant Layout to be designed to minimize environmental impact, ensure safe access and facilitate maintenance.*
- *Incorporate energy-efficient designs and sustainable materials to minimize the plants environmental foot print.*
- *Durable, corrosion–resistant materials for construction and ensure that all equipment and components meet specifications.*
- *Proper construction techniques and sequence construction activities to be implemented to minimize disruptions and ensure safety during construction.*
- *Thorough testing and commissioning to ensure that all systems and equipment function as designed.*
- *Robust monitoring and Control system required to be implemented to track plant performance, detect issues and enable timely interventions.*
- *Develop and implement a regular maintenance schedule and ensure that repairs are carried out promptly to prevent equipment failure.*
- *Ensure that operators possess necessary skills, knowledge and competencies to operate the plant safely and efficiently.*
- *Develop and implement comprehensive safety procedures and establish an emergency response plan to address potential incidents.*
- *Continuously monitor and optimize plant performance and plan for upgrades and expansions as needed to maintain compliance and efficiency.*
- *Regular environmental monitoring required to be conducted on plant performance and compliance with regulatory requirements and report to be submitted.*
- *Potential risks to be identified and contingency plans to be developed to implement measures to mitigate risks and ensure business continuity.*
- *The Contractor shall submit Eight (8) copies of each design and drawing to the Employer for approval.*

1.6 Additional Scope Details for Civil Works under Works – A

The scope of work for WwTP & TSPS shall include all civil works as per process requirements, including other facilities as listed below.

General points to be noted and implemented for all WwTP & TSPS

1. Approach Roads with gates shall be provided for WwTP site.
2. Plant internal roads shall be at least 3.5m. Additionally minimum 450 mm wide stormwater drain of RCC shall be provided on both/one side of the road. Also, 1.50m shoulder shall be provided for future road expansion.
3. The undulating ground shall be properly graded up to the site's Finished Ground Level (FGL) for the WwTP and TSPS sites. The FGL shall be at least 0.75m above the HFL for all sites. Wherever HFL does not exist, the site shall be evenly graded with respect to the FGL.
4. HFL provided in this document is only for guidance and, the same shall be ascertained during execution by a confirmatory Survey and Geotechnical report, as per site requirements, and shall be approved by the Engineer in charge.
5. WwTP site shall have an approach road of 5m width from the existing main road running in front of the gate.

6. The information provided in this document is only the minimum requirements at the site. The contractor shall visit the site and bid as per the actual site requirements. No additional claim or variation shall be allowed in case there is any change in the minimum requirement.
7. The HFL, FGL and EGL provided below are to be verified by the tenderers by visiting the sites.
8. 450 mm thick stone soling shall be provided for all buildings and minor structure foundations below PCC to improve the strength of the soil.
9. All trees and vegetation shall be removed as per the instructions of the Engineer in Charge after obtaining necessary permissions from the concerned authority.

1. <u>Channasandra 20 MLD WwTP with TSPS:</u>

1. A RCC Precast compound wall shall be constructed for a length of not less than 100 m.
2. An Approach road of 5m wide shall be provided for a length of not less than 100 m along the nala.
3. The Nala flowing along the boundary of the site shall be diverted by constructing one side Gabion wall on the plant side. The length of Gabion wall with chain link fencing shall be not less than 500m.
4. The Gabion wall with chain-link fencing shall also be constructed for a length of not less than 500 m all-round the site.
5. The Wet well may be preferably constructed by Well sinking method.
6. The site shall be filled up to the FGL (approximately 6 to 7 m) with approved soil. Pile foundations shall be adopted for the foundations of the Major structures and Stone piling / proper Ground improvement methods shall be adopted for Minor Structures, as per design requirements. Also, the contractor can propose any alternative acceptable foundations for the consideration of the engineer, as per the site requirements.
7. The Plant Internal roads shall be not less than 500 m in length.
8. Uprooting of 20-30 smaller trees may be required in the plant location.
9. FGL +857.750m
10. HFL +857.000 m

1.7 Scope of Work for Works – B

The scope of work includes procurement, laying, testing, and commissioning of sewer laterals and mains at Mahadevapura zones. The scope also covers the associated civil works, including the construction of machine holes, Lifting stations, and installation of pumps, saddle supports, pipe encasement, and anchor blocks.

The sewer line will be laid through urban areas, wherein frequent bends, conflict with other utilities might encountered along the right of way. A right of way to lay the sewer line shall be obtained in places, where the service road or land is not readily available.

The major length of sewer line is proposed to be laid underground. The exposed portion is to be laid above ground supported on saddles/ bridges. Some short lengths of sewer line laid underground needs concrete encasement while crossing the existing roads as well as at places of higher soil over burden.

Sewer line crossing major roads shall be laid using trenchless technology.

The Scope of Work under this contract includes but is not limited to the following in relation to Works-B:

- Identification of Sewer line Gaps in 110 villages Sewer network in Consultation with the Engineer In-charge for Conducting Survey.
- All preparatory work including clearing and leveling of site, site grading, formation of finished ground level (FGL), excavation, dewatering as required and disposal of all surplus earth to a suitable location and restore all the cutting roads to the original condition complete.
- Necessary Sewer alignment survey and geotechnical investigations and any other site investigations / site data complete including providing interconnecting existing machine hole & pipeline details of laterals with main sewers.
- Collection of details of existing machine holes between Gaps to facilitate design of sewer network.
- Collection of details of existing ISPS/TSPS for design of Sewer network.
- Existing utility survey has to be done wherever required. The contractor is required to carefully examine the location of the works & their alignments and to make special enquiries with all authorities concerning all Utility lines such as water, sewers, gas pipe, telephone (underground and overhead) lines, electric lines etc., and to determine and verify to his own satisfaction the types of materials Sizes, position and lengths of such utilities from authentic records. The Contractor shall be wholly responsible for the protection and facilitating relocation of such utilities as may be required.
- Submission of all Vendor Credentials & Quality assurance plans to obtain approval from competent authority before procurement of any type of material & equipment.
- All utility lines and structures, whether indicated on the drawings or not, which are to remain in service shall be protected by the contractor from any damage likely to result from his operations and relocate wherever necessary, shall be with the approval of the Engineer and the Utility Authority in accordance with all applicable laws, regulations, and standards. Items, components, or materials be used should be to the satisfaction of the concerned approving authority.
- Procurement and supply of materials, and all allied accessories, including setting out, laying, jointing, testing, dewatering as required, and commissioning of the sewer networks and pumping mains of the diameters and material as specified in the tender document.
- Setting out of alignment shall be as per approved construction drawings.
- Procurement and erection of machine holes with covers and other supporting accessories complete.
- High Pressure DI Machine hole covers supplied by the department are to be installed by the contractor in storm water drains for the Machine holes.
- Construction of pipe bedding, pipe supports, thrust blocks, anchor blocks etc., complete as per Specifications & drawings.
- Road restoration works to its original condition including all allied works shall be carried out as per Specifications & drawings.
- Construction of Sumps & Pump room as per specifications & drawings at lifting station, and procurement & installation of Lifting pumps including all electro-mechanical works and commissioning of the same.
- House service connection line to be installed.
- Interconnections with Works-A and other works as required to complete the work.
- Handing over of constructed facilities.
- Preparation and Submission of As-Built Drawings.

Notes:

- *Contractor shall carry out the complete survey of sewer networks as indicated in the tender drawings and shall submit the same data, village-wise and drainage zone-wise, to the Employer.*
- *Good for Construction Drawings (PDF files) issued by the Consultant shall be printed by the Contractor (A1 Drawings) as per the requirement of the Engineer In-charge, and the same shall be submitted to obtain necessary approval from the competent Authority.*
- *The Contractor shall submit Eight (8) copies of each design and drawing to the Employer for approval.*
- *Any crossing of the gravity sewer lines & pumping mains across National Highway, State Highway, Heavy traffic roads, and Railways shall be carried out with trenchless technology and with prior approval from the concerned authority in accordance with all applicable laws, regulations, and standards complete.*
- *Contractor to submit Construction Approach and Methodology, before the start of each/any type of construction activity at the site.*
- *It shall be mandatory for Contractor to take prior approval on EMP and EMoP document based on the requirements as specified in Part 18 of the Tender Document.*

1.8 Funding Agency and Financing

Funds for the Contract are being provided by the World Bank and State Government of Karnataka.

1.9 Treated Effluent and Sludge Characteristics

The treated effluent characteristic for WwTP shall comply with the following discharge standards given in the Table below:

Parameters	Unit	Value
TREATED EFFLUENT QUALITY REQUIREMENTS - DISCHARGE		
pH - Instantaneous range	-	6.5-8.0
BOD_5 at 20°C - Maximum monthly average	mg/L	10
COD - Maximum monthly average	mg/L	50
TSS - Maximum monthly average	mg/L	10
TN - Maximum monthly average	mg/L	10
Total Phosphorus - Maximum monthly average	mg/L	1
Residual Chlorine - Instantaneous	mg/L	1
Fecal Coliform – Maximum Monthly average	MPN/100 mL	100
Fecal Coliform – Ceiling Limit (in any day)	MPN/100 mL	230
TREATED SLUDGE QUALITY REQUIREMENTS		
Sludge Quality	-	Undigested dewatered sludge
Minimum Solid Concentration in Dewatered Sludge	%	20

Parameters	Unit	Value
NOISE LEVELS		
Noise Levels inside the Process Buildings (Maximum)	dBA	80
Noise Levels at Plant Boundary (Maximum)	dBA	60

Refer Part 5, Volume 2, Section 7 for Sampling and analysis requirement.

Parameters	Unit	Value
TREATED EFFLUENT QUALITY REQUIREMENTS FOR REUSE (APPLICABLE AS SPECIFIED)		
Reuse Flow	MLD	10
Turbidity	NTU	< 2.0
SS	mg/L	As arising
TDS	mg/L	< 1000
pH	-	6.5-8.5
Temperature	°C	Ambient
Oil & Grease	mg/L	Nil
TN	mg/L	< 5.0
BOD_5 at 20°C	mg/L	< 5.0
COD	mg/L	< 30.0
TP	mg/L	< 1.0
Residual Cl	mg/L	~1.0
Fecal Coliform	MPN/100mL	Nil
Color	-	Colorless
Odour	-	No foul odour

Refer Part 5, Volume 2, Section 7 for Sampling and analysis requirement.

1.10 Site Conditions

Each Plant shall be designed and constructed taking into account the following:

Annual Average Ambient Temperature : 27º C (Minimum 15ºC - Maximum 45º C)

Relative Humidity (maximum) : 75 %

Site Conditions : Tropical

The plant shall be designed to suit the ambient temperature mentioned above with the Contractor making due allowance in his designs for the increased temperatures experienced by Plant exposed to direct sunlight.

1.11 Minimum Design Life

The Plant components shall be designed and constructed to provide the minimum service life listed below for each component.

Reinforced Concrete Structures	:	60 Years
Buried Piping	:	60 Years
Other Civil Structures	:	50 Years
Steel Structures	:	50 Years
Buried Earth Electrode System	:	40 Years
Mechanical Equipment	:	20 Years
Electrical Equipment	:	15 Years
Control Panels	:	15 Years
Instrumentation Systems	:	10 Years
Diffusers	:	7 Years
Computer System	:	7 Years
All type of Server and Computer based Software's	:	Should be updated to latest version

1.12 Access for Other Contractors

The Contractor shall allow reasonable access to other Contractors engaged on the Site or on areas adjoining the Site to carry out their work. In the event of a dispute over access or priority between Contractors, the Engineer shall be informed in writing. The Engineer shall inform all parties concerned in writing of his decision.

Where any part of the Works is associated with or in physical contact with plant supplied under a separate contract, the Contractor shall satisfy himself that the work carried out by the other Contractor is consistent with the correct operation of the Plant. In the event of the Contractor considering any work being carried out or any work already completed to be detrimental to the ultimate operation of the Plant, he shall report the matter to the Engineer.

If the work of the Contractor is delayed because of any acts or omissions of any other contractor, the Contractor shall have no claim against the Employer on that account other than for an extension of time.

Works of other Contracts taking place on the same Site or adjoining the Site include but are not limited to the following:

1. Providing and laying laterals sewers and house connection chambers for 110 Villages;
2. Regular operation and maintenance work of existing sewers, ISPS, TSPS and STPs by BWSSB.

1.13 Survey and Geotechnical Data

Contractor shall carry out independently fresh survey, geotechnical investigation and all other details necessary for proper planning, detailed design and execution of all works under this Contract. The Contractor will be required to provide full details of the survey and geotechnical investigations of works for approval of the Employer.

1.14 Contractor's Bengaluru Satellite Office

Contractor shall designate an Engineering Manager (Lead design and Technical Support) who is responsible for the complete works design including preparation of Detailed Designs and obtaining all required Detailed Design approvals. The Contractor shall also designate Design Leads for each design discipline required. The Contractor shall mobilize the entire Design Team to a Satellite Office in Bengaluru. This design office shall be in addition to its Construction Site Office.

The Satellite Office shall be staffed to facilitate and expedite submittals of Detailed Designs. Contractor shall designate a Deputy Design Manager who reports directly to the Contractor's Engineering Manager and will be stationed full-time in the Bengaluru Satellite Office through the Detailed Design preparation, submittal and approvals. Contractor shall also designate Design Leads for each design discipline required stationed in the Bengaluru Satellite Office who will do design production. The Deputy Design Manager and Design Leads will communicate directly with Employer's staff and its designees throughout Detailed Design preparation, submittal, review and approval, as well as during the same procedures for submittals for testing and commissioning and all other design related submittal required in accordance with the Contract. The Satellite Office Staff in conjunction with the Contractor's Home office staff will be responsible for timely response to Employer's comments related to the Detailed Design.

The Contractor's Engineering Manager will be responsible for the efficient coordination of the Satellite Office, Home Office and Employer's staff & its designees such that the design work proceeds expeditiously.

The minimum Design Staff assigned to the Satellite Office shall be as follows, the office shall also include sufficient administrative staff and a attender to support the office.

S. No.	Position	No. of Position	Minimum Experience in Similar Works (years)
1	Engineering Manager	1	10
2	Deputy Design Manager	1	10
3	Design Lead-Process	1	8
4	Design Lead-Sewer Network	1	8
5	Design Lead- Civil	1	8
6	Design Lead- Structural	1	8
7	Design Lead- Mechanical Process	1	8
8	Design Lead- Mechanical Building Services	1	8
9	Design Lead- Electrical	1	8
10	Design Lead- ICA	1	8
11	Design Lead- Buildings &Architecture	1	5
12	Design Lead-Health and Safety	1	8
13	Support Engineers	4	5
14	CAD Operators	As per Requirement	8

S. No.	Position	No. of Position	Minimum Experience in Similar Works (years)
Notes: *1) Minimum relevant experience shall be after the completion of Engineering Graduation in respective discipline.* *2) All the respective staff shall have experience in wastewater collection, WwTP and Sewage Pumping Stations in respective discipline.* 3) *Contractor's Satellite Office shall have minimum office space of 150m^2 and shall facilitate Conference Hall, Engineering Cabins, Audio & Visual Communication system and all other minimum facilities as per applicable laws.*			

The Contractor shall operate and maintain its Satellite Office throughout the Detailed Design preparation, submittal and approval process. Approval of the Detailed Design shall be determined when all submittals have received a review designation of "A-Approved" and final copies of all Detailed Designs have been submitted.

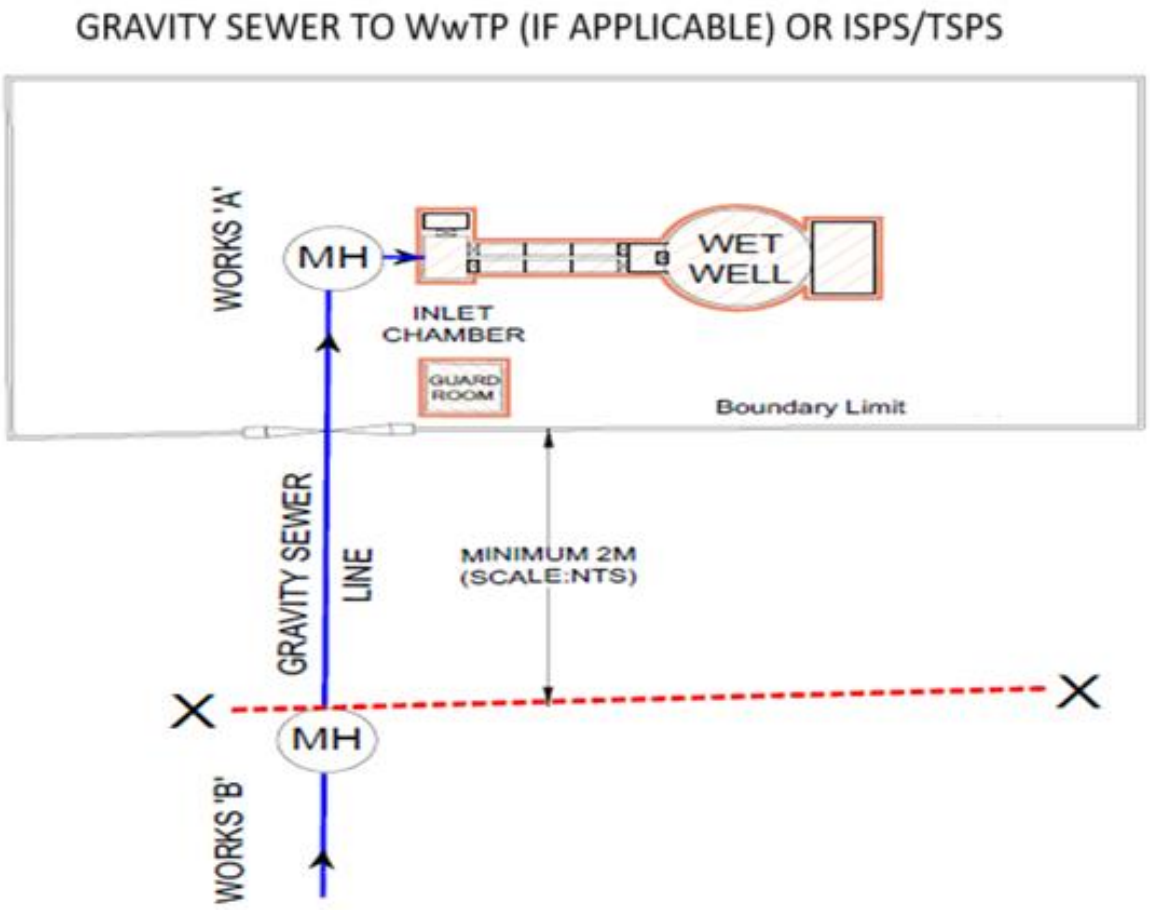
1.15 Battery Limits between Works - A and Works – B

The following are the Battery Limits (interfaces between) Works - A and Works - B for the following cases:

Gravity Sewer to WwTP (if applicable) or ISPS/TSPS

The interface between Works – A and Works – B shall be the first flexible joint downstream of the machine hole outside of the WWTP Site (Line XX on the following Figure). The machine hole shall be located such that the edge of the machine hole is located minimum 2 m from the centre of the fence or wall (which shall be constructed along the boundary of the Site for Works - A in which the TSPS/ISPS and WWTP shall be constructed), whichever is provided.

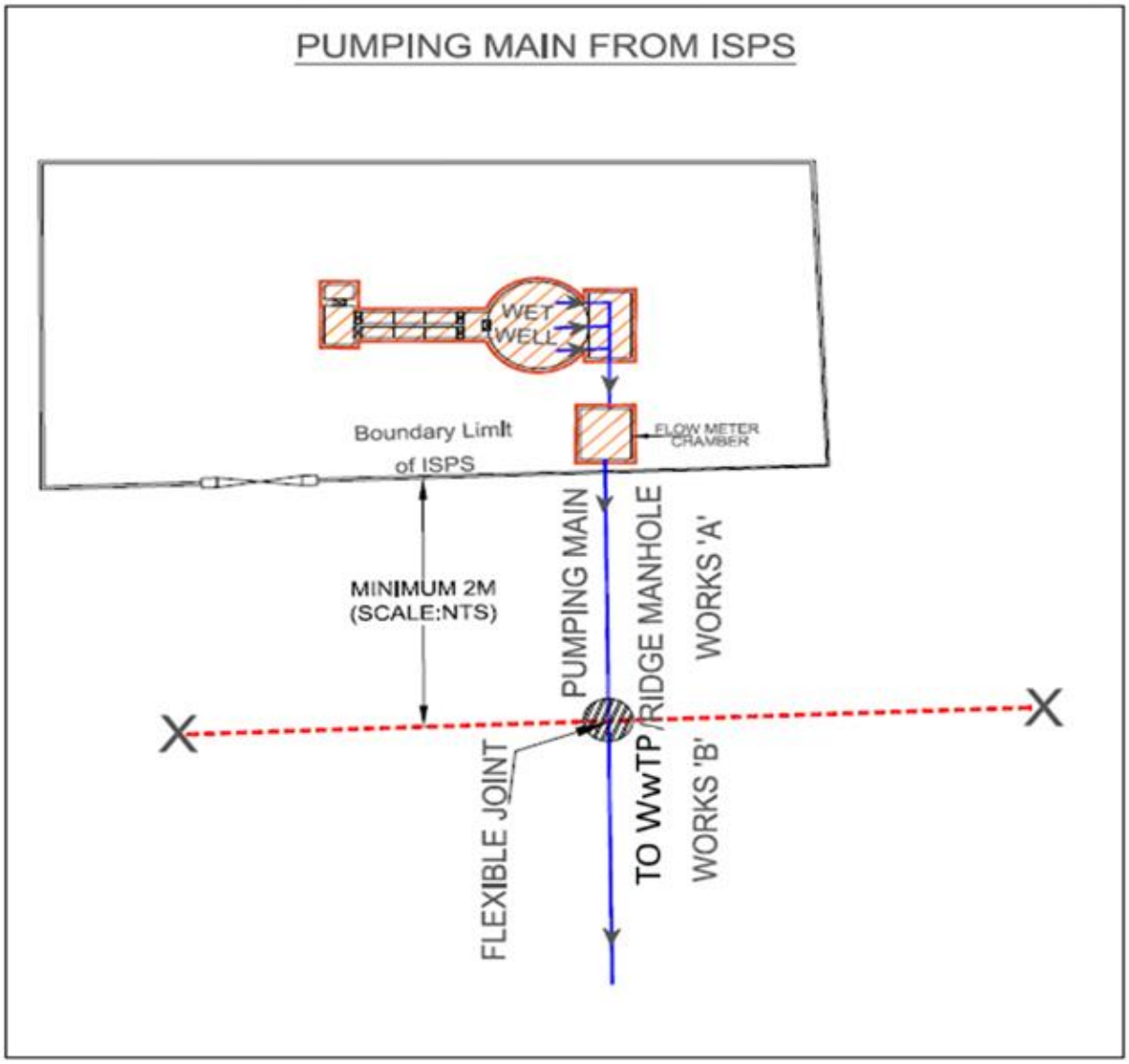
Works downstream of Line XX shall be included in Works – A, whereas Works upstream of Line XX shall be included in Works – B. For clarity Works in Works – A therefore includes a short length of sewer, which is outside the boundary of the Site for Works – A, as described in the above paragraph.



Pumping Main from ISPS

The interface between Works – A and Works – B shall be the first flexible joint on the pumping main outside the boundary of the ISPS Site (Line XX on the following Figure). The above joint shall be located such that the centre line of the joint is located at minimum of 2 m from the centre of the fence or wall (which shall be constructed along the boundary of the Site for Works – A in which the ISPS shall be constructed), whichever is provided,

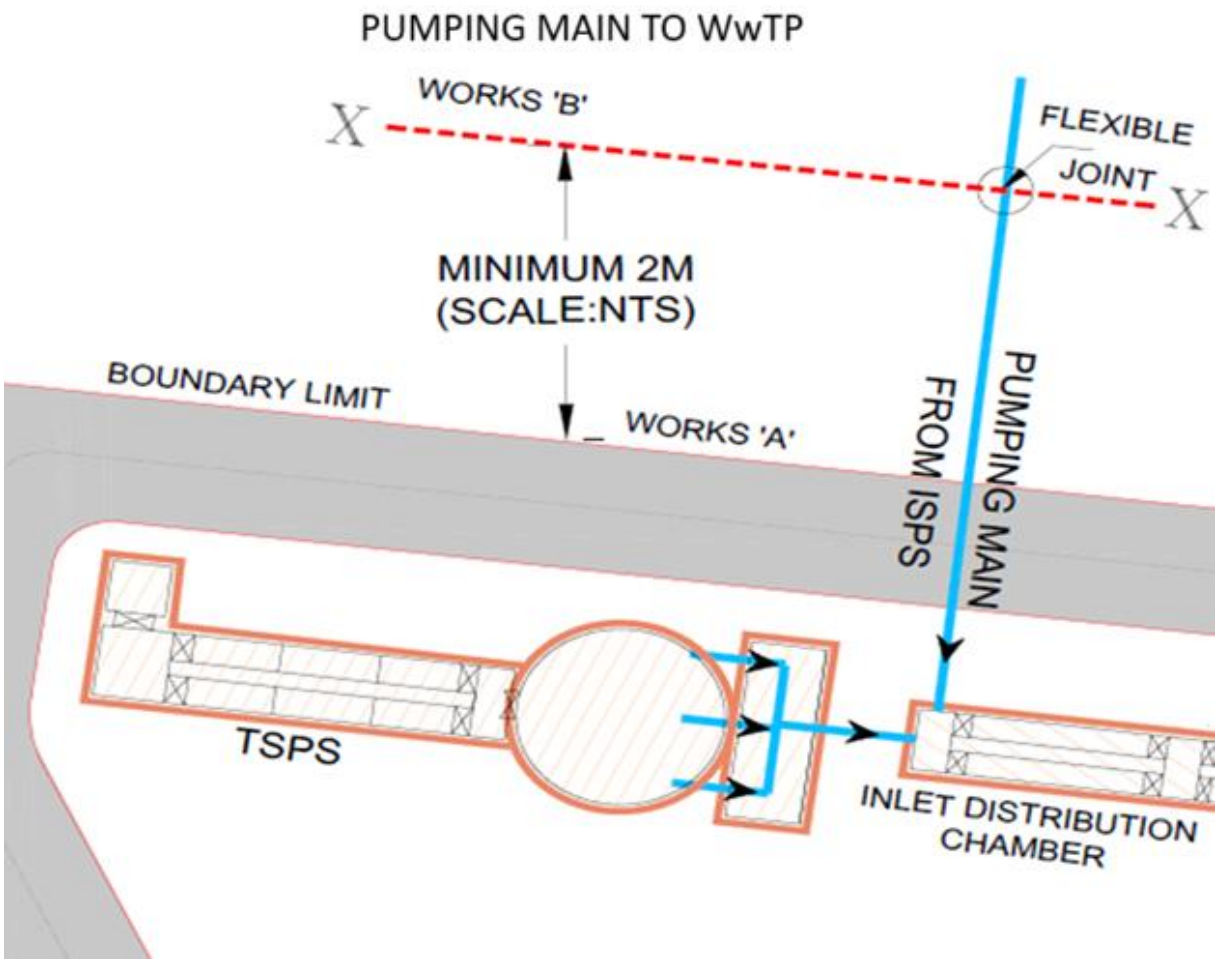
Works upstream of Line XX shall be included in Works – A, whereas Works downstream of Line XX shall be included in Works – B. For clarity Works in Works – A therefore includes a short length of Pumping Main, which is outside the boundary of the Site for Works – A, as described in the above paragraph.



Pumping main to WwTP

The interface between Works – A and Works – B shall be the last flexible on the pumping main outside the boundary of the WWTP Site (Line XX on the following Figure). The above joint shall be located such that the centre line of the joint is located a minimum of 2 m from the centre of the fence or wall (which shall be constructed along the boundary of the Site for Works – A in which the WWTP shall be constructed), whichever is provided.

Works upstream of Line XX shall be included in Works –B, whereas Works downstream of Line XX shall be included in Works –A. For clarity Works in Works – A therefore includes a short length of Pumping main, which is outside the boundary of the Site for Works – A, as described in the above paragraph.



Connections to Existing Facilities under Works - B

Connections of Proposed Sewers to Existing Machine holes

All sewers shall be connected to existing machine holes and not directly to the sewer in accordance with the levels and other details provided by the Engineer.

The Contractor shall carry out all works such that there is no adverse effect on the flow in the machine hole that the sewer is to be connected to, as well as all sewers upstream and downstream of the machine hole. Works shall preferably be carried out when flows in the existing sewer are low compared to the average flow. All work shall be carried out without effecting the structural integrity, water tightness or other requirements/features relating to the construction of a new machine hole.

Works shall include but not be limited to: breaking existing machine holes (including for connection of backdrop, where required); connection of new pipes, making good and sealing; breaking existing benching, construction of new benching and making good; removal of existing step irons and installation of new step irons, where required due to orientation/location of new sewer; relocation of machine hole cover, where required due to orientation/location of new sewer.

Connections of Proposed Pumping Mains to Existing Machine holes

Connections shall be made as described for Connections of Proposed Sewers to Existing Machine holes.

1.16 Interface with Other Contracts

The Works under this Contract will physically interface with Works under the Contract for laying lateral sewers for 110 villages. The Contractor for this contract shall co-ordinate with Employer and the Contractors for the above Contract as applicable and ensure that all interfaces are designed, constructed, installed, tested, commissioned, operated, and maintained properly to provide a fully functional system meeting all applicable performance requirements.

The Contractor for this Contract shall be fully responsible for independently field-verifying any and all information he considers relevant in order to provide a fully functional system.

1.17 Sectional Completion of Works

Sectional Completion of Works is required by the Employer and is included in Volume 1 of the Tender Document. The Contractor shall in particular note the importance and sequence of Sectional Completion considering also the interface between existing facilities and those being implemented under a separate Contract.

The Contractor should note that the lateral sewers of 110 villages, which discharge sewage to the main sewers to be implemented under this Contract are being implemented under a separate contract, which is either in progress or completed. The Contractor shall familiarize himself with the schedule for the above Contract and monitor the progress on a regular basis.

In the event that construction of the TSPS/WwTP is completed before wastewater is available at a TSPS/WwTP, the Contractor shall properly maintain the TSPS/WwTP in an inactive state until such time as wastewater becomes available. Further, all the components of the plant shall be adequately secured, protected, maintained, and exercised according to manufacturers' instructions during this inactive period. This inactive period shall be considered part of the Operation and Maintenance Period.

The monthly price for maintaining each WwTP in this contract in an inactive state shall be decided by mutual agreement between the Employer and the Contractor as necessary.

Specified activities related to commissioning, testing, demonstration of performance shall be performed when wastewater becomes available at the WwTP. No additional payment shall be made to the Contractor for such deferred activities.

End of Part 1

PART 2

THE SITE

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PART 2

THE SITE

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PART 2

THE SITE

2.1 Location of the Sites

Works-A:

The proposed Wastewater Treatment Plant is to be constructed in the village of Channasandra, under the Mahadevapura Zone.

Works-B:

Proposed Sewerage System

The sewerage system under the package comprises areas falling under Mahadevapura zones.

Details of Proposed Size and Length of Sewer for Mahadevapura Zones

Sl. No.	Zone	Diameter	Length (m)
1	Mahadevapura	250mm SW Line (DWC)	40000
		300mm SW Line (DWC)	2000
		Grand Total Length	**42000**

2.2 Access to the Sites

The Employer will afford to the Contractor access to and possession of the Site for carrying out the Works. The Contractor shall be deemed to have inspected the WwTP/LPSs, sewer network sites, including access, before submitting their Bid.

The Contractor shall ensure that the plant/LPSs & other components offered are of a size and weight or can be divided into sections of a size and weight suitable for access to the place of installation.

The Contractor shall ensure that equipment used for installation purposes shall be able to gain access and position for such purposes.

The WwTP and LPS location details are provided below:

2.2.1 Details of WwTP

SI. No.	WwTP Location	Average Flow
1	Channasandra	20 MLD

2.2.2 Details of LPSs

SI. No.	LPS Locations	Average Flows
1	Halasahalli	0.9 MLD

2.3 Maintenance of the Site

The Contractor shall be responsible for maintaining all the site structures, buildings, equipment, contract display board, and related services until expiration of the contract period or until such time as the aforementioned facilities are removed with the Engineer's prior approval, whichever is earlier.

At each proposed WwTP/LPSs site under the contract, access main-gate and access road extension shall be provided by the Contractor.

2.4 Areas outside the Site

In the event of the Contractor making use of any special or temporary way leave or accommodation acquired by him or any pit for the disposal of surplus materials, or any borrow pit or quarry, he shall obtain the written consent of the owner, occupier or authority having charge of the land in which such way leave, accommodation, or pit is situated and shall make a written record, acknowledged and signed by the owner, of the condition of the surface of that land before entering thereon, with liberal use of photographs.

The Contractor shall permit the Employer, the Engineer, and any person authorised by the Employer access for the purposes of the Contract to any such special or temporary way leave or additional accommodation.

In the event of the Contractor making use of any special or temporary way leave or additional accommodation made available to him by the Employer for the purpose of the Contract, the land in which such way leave, or accommodation is situated shall be deemed to be part of the Site. On completion of the works in this area, the Contractor shall reinstate the area to its original condition to the satisfaction of the Engineer. For the purposes of this Clause, "accommodation" shall be deemed to include housing, offices, workshops, warehouses, and storage areas.

2.5 Road Works

The Contractor shall obtain all necessary permits for carrying out works, such as excavation on public roads, and shall liaise with the relevant authorities regarding the timing and execution of the road works.

The Contractor shall be responsible for establishing and maintaining temporary road diversions for the duration of the road works. The road shall be kept open at all times during the road works period, and the work shall be carried out in such a manner as to minimise the disruption to traffic. The Contractor shall reinstate all roads to the satisfaction of the Engineer upon completion of the works.

2.6 Maintenance of Existing Access Roads

The Contractor shall only use existing access roads within the Site boundary which are necessary for the execution of the Works. The Contractor shall obtain the Engineer's approval in writing before utilising existing access roads within the Site. Once the Engineer's approval has been given, the Contractor shall be solely responsible for the maintenance of the existing site access roads. This responsibility shall continue until the completion of the Defects Notification Period, or an earlier date as the Engineer may advise the Contractor in writing. Such maintenance work shall include general upkeep and any necessary repairs to damaged road surfaces, pavement, drainage, associated slopes, etc., to a standard at least equal to their original condition. While carrying out such maintenance work, the Contractor shall make arrangements to maintain through passage for the Employer and their staff

vehicles and also those of other contractors over these access roads. Such arrangements may include temporary diversions, all of which are subject to the approval and satisfaction of the Engineer.

The Contractor shall not run tracked or unsprung vehicles on surfaced roads without the written approval of the Engineer, who may require that planking or some other protective material be used to protect the road surface.

2.7 Clearance of the Site

The Contractor shall clear the Site to the extent required by the Engineer for checking the setting-out.

Clearance of the Site shall also include demolition and removal of all articles, objects, and obstructions which are expressly required to be cleared.

The Contractor shall ensure that the parts of the Site to be occupied by the Permanent Works are clear and shall maintain the remainder of the site as may be required for access and temporary works areas.

The Contractor shall remove the material arising from such clearance and dispose-off it in a manner and at a location that are both in compliance with all applicable laws and regulations.

The Contractor shall backfill the cavities and losses of soil resulting from clearing the parts of the Site not subsequently to be occupied by the Works, using the specified materials and procedures.

The Contractor shall not clear the Site of any existing structure(s) without the prior written instruction of the Engineer.

2.8 Clearance and Reinstatement of the Site on Completion of the Works

Upon completion of the Works, the Contractor shall clear all temporary works areas and temporary access roads, and reinstate the areas to their original condition, to the satisfaction of the Engineer.

2.9 Access for the Employer and Engineer

The Contractor shall permit the Employer, the Engineer and any person authorised by the Employer or the Engineer including workmen of the Employer, other Contractors or utility undertakings access for the purposes of the Contract to all areas of the site and to any additional accommodation or temporary wayleave for the duration of the Contract period.

2.10 Water Supply at Site

The Contractor shall make his own arrangements for water supply at the site for the duration of the contract. The Contractor shall ensure the quality of the water remains suitable for the purpose for which it is intended. The Contractor shall also conduct weekly tests for water quality and comply with the quality requirements. Wastewater shall be disposed of clear of the Site to the satisfaction of the Engineer so as to maintain the hygienic condition at the site and no damage or complaint.

Exploration of groundwater for construction purposes, either directly or indirectly, is not allowed under this contract. Contractor shall take prior approval for the source of water used for construction activities, and source of such water shall not be groundwater or water designated for drinking purposes.

It is highly encouraged to use the tertiary/secondary treated wastewater for construction activities where project components (TSPS, WwTP, ISPS, LPS, Sewer Network and Rising Main) under this contract is within 10kms radius of existing operating WwTP(s) and such tertiary/secondary treated wastewater is available to contractor at reasonable cost from BWSSB upon request. However, the contractor shall ensure that such tertiary/secondary treated wastewater shall meet the water quality suitable for the purpose for which it is intended. Further, it is the contractor's responsibility to ensure "non-detectable Fecal Coliform" standards for tertiary/secondary treated wastewater, wherever it has the possibility of direct or indirect human contact during construction activities, by the Contractor at his own cost.

Nevertheless, at minimum, the water requirement for the Contractor's batching plant and the water requirement for hydro-test(s) shall be met by tertiary/secondary treated wastewater.

2.11 Toilets, Latrines, Washing Facilities, and Wastewater Disposal

Throughout the period of construction of the Works, the Contractor shall provide and maintain sufficient toilets, and wash facilities for use by his employees that are clean. He shall ensure that his employees make proper use of the toilets and not foul the site.

Where, all wastewater generated at the facilities on site shall be connected to the nearest public sewer, or if this is not practicable, the Contractor shall provide an adequately sized septic tank and soak pit.

After completion of the works, the temporary toilets, latrines, washing facilities, septic tanks, and soak pits shall be removed, all ground disinfected, and the surface restored to its original condition to the satisfaction of the Engineer.

2.12 Electricity for Contractor's Use on Site

The Contractor shall be responsible for the provision of an electric supply to the site, an energy meter, and the distribution of the supply in accordance with the Conditions of Contract (including Particular Conditions of Contract).

The installation shall comply with all the relevant regulations, Indian Standards and Codes of Practice, and Health and Safety requirements. The Contractor shall take all precautions to ensure that the installation is safe and injury to personnel or damage to plant and buildings is avoided. The Contractor shall be fully responsible for all safety aspects.

The Contractor shall test the temporary site power distribution system, including the energy meter, every 3 months for compliance with the relevant standards.

2.13 Camp Facilities

The Contractor shall construct and maintain to the Engineer's satisfaction a camp to provide living accommodation for all the Contractor's staff and operatives who have no other local accommodation. The Contractor's camp shall be located near, but not on, the Site itself, at a location approved by the Engineer.

Responsibility for providing all services to the living quarters and compliance with all sanitary laws and other laws and regulations shall be borne by the Contractor. Security and the fencing of these areas shall be the responsibility of the Contractor.

2.14 Compressed Air Use on Site

The Contractor shall provide the necessary compressed air plant and equipment required for the construction of the Works.

Electrically driven compressors connected to the site electricity supply shall not be used. Diesel engine driven compressors shall not be sited within buildings or in a location that may cause a health hazard to personnel owing to exhaust fumes or noise.

2.15 Refuse Disposal on Site

Refuse and rubbish of every kind shall be removed from the Site and disposed of by the Contractor at his own expense, frequently and regularly at a minimum period of one week to keep the Site in a wholesome and tidy condition to the satisfaction of the Engineer.

2.16 Safety and Security on Site

The Contractor shall at all times maintain safe work methods and procedures and shall comply with all enactments, regulations, and working rules relating to safety, security, health, and welfare of all persons who may be affected by his work.

In particular, he shall ensure that only persons who are properly trained for their duties are employed and that appropriate, approved tools, safety equipment, and procedures are used.

Nothing which has been written into or omitted from the Employer's Requirements shall be taken to relieve the Contractor from his obligations under this clause. No clause in the Employer's Requirements shall prevent the Contractor from drawing the attention of the Engineer to any feature of the Works which is not consistent with normal safety practices nor prevent him from putting forward proposals at any time which would increase the safety of the installations.

Not later than four weeks before work commences on the Site, the Contractor shall submit to the Engineer his comprehensive plans and proposals relating to all the aspects of health and safety on the Site. The proposals shall be appropriate for all grades of labour and personnel who will work on or visit the Site on behalf of the Employer, Engineer or Contractor.

The Contractor shall appoint **Health & Safety Engineers (Accident Prevention Officers**), as stated in Volume 1, Section III of Evaluation and Qualification Criteria who shall be responsible for the implementation of site procedures as per relevant standards. The responsibilities of the above engineers shall include but not be limited to:

- safety;
- working in hazardous areas;
- permit to work;
- fire and smoking regulations;
- first aid;
- warning signs;
- trenching scaffolding and other construction structures;
- safety barriers;
- protective clothing and equipment;
- safety training;

- safety meetings and inspections;
- health and welfare.

The Engineer shall have the authority to halt any activity or work in any area where there is a breach of the published site safety rules or where health and safety is otherwise endangered.

The Contractor shall ensure that all other Contractors working on the Site also follow established health and safety procedures. The Contractor shall bring any violation of Site safety rules by others to the attention of the Engineer in writing.

2.17 First Aid and Life-saving Apparatus on Site

The Contractor shall provide on the Site such life-saving apparatus as may be appropriate and an adequate and easily accessible to workmen and all other Staff a first aid outfit/station or such outfits/station as may be required in any government ordinances, factories acts, etc, published and subsequently amended from time to time. Each station shall be properly equipped and shall be under the charge of a suitably qualified and trained staff member. In addition, an adequate number of persons who are permanently on the Site shall be instructed in their use, and the persons so designated shall be made known to all employees by the posting of their names and designations in a prominent position (positions) on the Site.

The Contractor shall arrange for medical services to be promptly available as and when necessary and shall also provide for the transport of serious cases to the nearest hospital. These and all other arrangements shall be included in the Contractor's Safety Plan.

2.18 Electrical Safety on Site

The Contractor shall be responsible for the electrical safety of all Plant and equipment supplied and installed. Whilst any equipment is being installed or tested, the Contractor shall ensure that all necessary precautions are taken to safeguard personnel working on site. If necessary, this shall include fencing off areas which are considered to pose a risk, and erecting warning notices.

The Contractor shall be responsible for ensuring that the electrical installation is carried out by suitably trained and competent personnel who execute the work in a safe manner.

The Contractor shall be responsible for the permit at site for the operation of electrical equipment installation and testing. This system shall regulate the installation, the energisation, and use of electrical Plant and equipment installed, and the method of work adopted.

2.19 Noise

The Contractor shall ensure that the operations entailed in the construction of the Works do not cause annoyance to others working on the Site or to persons living adjacent to the Site.

2.20 Warning and Safety Signs

During construction of the Works, statutory safety signs shall be adequately provided throughout the Works, both indoors and outdoors. These safety signs shall cover mandatory, prohibition, warning, emergency, fire-fighting and general notices. All signs shall be positioned around the Works at highly

visible points. Provision of signs and the positions of signs shall be subject to the Engineers approval. Special attention shall be given to areas designated hazardous.

Warning signs shall be in English, Kannada and Hindi Languages.

2.21 Site Working Hours

The Site working hours are detailed in the Contract Data.

The Contractor shall not extend the working hours without the prior approval of the Engineer.

2.22 Delivery to Site

The Contractor shall be responsible for the transportation, handling, and delivery to the site of all the Plant and equipment. The proper storage and protection of all Plant and equipment at the Site shall be the Contractor's responsibility.

The Contractor shall verify all items against the packing lists immediately upon delivery to the Site and inspect for damage and shortages. Damages and shortages shall be remedied with the minimum of delay.

The Contractor may, with the prior approval of the Engineer and at no extra cost to the Employer, make arrangements for any other contractor or agent to take delivery of, unload and store the Plant on the Site on behalf of the Contractor.

All deliveries shall take place during the Contractor's normal working hours.

2.23 Protection from Weather and Storage

An area and/or building on the Site for use by the Contractor for the storage of Plant prior to erection will be subject to the Engineer's approval.

The Contractor shall provide all facilities for the safe and proper storage of Plant and equipment, as recommended by the manufacturers, with particular consideration being given to temperature, rain, sunlight, wind, and ground conditions.

The Contractor shall remain responsible to the Employer for the care and insurance of the Plant and the provisions of this Clause shall not relieve the Contractor of any of his liabilities under the Contract.

The Contractor shall lay stored Plant items out to facilitate their retrieval and use in the order as recommended by the manufacturer.

Stacked Plant items shall be protected from damage by spacers on load-distributing supports and shall be safely arranged. No metalwork shall be stored directly on the ground.

Small Plant items shall be held in suitable bins, boxes or racks and be clearly labelled.

Items of Plant shall be handled and stored so that they are not subjected to excessive stresses and so that protective coatings are not damaged.

The Contractor shall comply with the manufacturer's package and plant markings concerning the use and location of lifting slings, chains, and hooks, and all other handling, storage, protection, and installation instructions.

2.24 Contract Signboards

The Contractor shall supply and erect signboards at locations to be specified by the Engineer. The layout and dimensions of the signboards and their construction shall be to the approval of the Engineer, and the lettering in Kannada, Hindi, and English Languages shall be black on a white background.

2.25 Advertising

The Contractor shall not use any part of the Site for any form of advertising without the prior written approval of the Engineer.

End of Part 2

PART 3

GENERAL REQUIREMENTS

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PART 3

GENERAL REQUIREMENTS

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PART 3

GENERAL REQUIREMENTS

3.1 Introduction

This Part sets out the technical requirements that are general to the Contract.

3.2 Technical Standards and Regulations

Except where otherwise specified in the bid document, plant, materials, and workmanship shall comply with the requirements of the relevant Indian Standards (hereinafter referred to as IS) issued by the Bureau of Indian Standards. Other equivalent National or International Standard Specifications such as those issued by the International Organisation for Standardisation (ISO) or the International Electrotechnical Commission (IEC) may be substituted by the Contractor (as long as they are more stringent than the equivalent IS) at the sole discretion of the Engineer or as may have been agreed in the Contract. All standards used shall be the current and latest version.

The Electrical installation shall comply with all relevant statutory regulations and standards current as of the bid date, unless otherwise specified in the Employer's Requirements. Electrical installations shall, where relevant, be in accordance with the Indian Standards Code of Practice for Electrical Wiring Installations IS 732-2019, National Electrical Code of India 2023 (SP 30), Central Electricity Authority (Measures relating to Safety and Electric Supply) Regulations, 2023.

All materials, plant, and equipment shall be new. All materials and workmanship not fully specified herein or covered by an approved standard shall be of such kind as is used in first class work and suitable to the climate in the project area.

Where reference is made in the Specification to a British Standard Specification (hereinafter abbreviated to `B.S.') issued by the British Standards Institution of 2, Park street, London W.I., or to an Indian Standard Specification (I.S.) issued by the Bureau of Indian Standards, (earlier known as Indian Standards Institution), Manak Bhavan, 9 Bahadur Shah ZafarMarg, New Delhi 110 002, or American Society for Testing and Materials (ASTM) issued by ASTM 1916 Race Street, Philadelphia, P.A., 19103, U.S.A. or American National Standards Institute (ANSI) issued by ANSI 1430, Broadway, New York, N.Y., 10018, U.S.A. or to any other equivalent standard it shall be to the latest revision of that Standard at the Tender opening date.

The Contractor may propose, at no extra cost to the Employer, the use of any relevant authoritative internationally recognised Reference Standard, including Indian Standard (IS) and British Standards European Norm (BS EN).

All details, materials, and equipment supplied, as well as workmanship performed, shall comply with these Standards. If the Bidder offers equipment to other Standards, the equipment/material should be equal or superior to those specified and shall be subject to approval by the Engineer and full details of the difference shall be supplied by the Contractor.

In the event of conflict between this Specification and the Codes for equipment, the most stringent provision shall govern, except as otherwise approved by the Employer. Certain Specifications issued by national or other widely recognised bodies are referred to in this Specification. Such specifications

shall be defined and referred to hereinafter as Standard Specifications. In referring to the Standard Specifications, the following abbreviations are used:

IS	:	Indian Standard
ANSI	:	American National Standards Institute
API	:	American Petroleum Institute
ASME	:	American Society of Mechanical Engineers
ASTM	:	American Society of Testing and Materials
AWS	:	American Welding Society
AWWA	:	American Water Works Association
ISO	:	International Organization for Standardization
JIS	:	Japanese Industrial Standard
DIN	:	Deutsches Institut für Normung
BS	:	British Standard
JWWA	:	Japanese Water Works Association
IEC	:	International Electrotechnical Commission
IEE	:	Institution of Electrical Engineers
IEEE	:	Institute of Electrical and Electronics Engineers
NEMA	:	National Electrical Manufacturers Association
AGMA	:	American Gear Manufacturers Association

3.3 Precedence of Employer's Requirements

The Requirements specified in the particular requirements part, shall be in addition to those specified in the general requirements part. In the event of a conflict between the parts, the requirements of the particular requirements sections shall take precedence.

3.4 Units of Measurement

All designs, drawings, specifications, and manuals shall use SI units, and all measurements, dimensions, and performance data shall be quoted in those units.

3.5 Programme

In accordance to Volume 1 of the Particular Conditions of Contract, the Contractor shall submit within the stipulated time a detailed contract programme for approval, which shall include details of all temporary and permanent works, construction procedures and methodologies.

In addition to the requirements set down in the Conditions of the Contract the programme shall include the following details:

(a) Contractor's organisational family tree for the Contract, including details of all site supervisors and their responsibilities.

(b) A statement giving the numbers and categories of supervisory and technical staff and skilled and unskilled labour to be employed on the Works.

(c) A list and type details of major constructional plant (including vehicles) which the Contractor proposes to employ on the Works, including programmed dates for order and delivery.

(d) Details of the Contractor's methods of working for all operations.

(e) A statement giving the proposals for location or locations and sizes of offices, workshops, and stores at the Site.

(f) A complete resource allocation showing the number of units and allotted times for each unit of constructional plant, materials, and labour allocated to each part of the Works.

The programme shall be co-ordinated to take into account the requirements of climatic, groundwater, and other conditions to provide for the completion of the Works per the Contract.

The programme shall be prepared using MS Project software and shall be submitted in both soft copy (editable copy) and paper.

3.6 Contract Management

The Contractor shall be responsible for the administration of the Contract from the award of the Contract through design, manufacture, manufacturer's works testing, and delivery of the Plant to the Site, installation, testing, and performance testing to final takeover. For this purpose, he shall nominate a Contractor's Representative in accordance with Volume 1 of the General Conditions of Contract, who shall be fully responsible for and undertake this administration.

Specific responsibilities of the Contractor's Representative shall be:

(a) The sole representation on behalf of the Contractor in all discussions, correspondence and matters relating to the Works.

(b) The co-ordination and monitoring of Contract progress, which shall include the preparation of the Contract programme, monitoring of progress, and submission of monthly progress reports. At the discretion of the Engineer, regular meetings shall be held at which the Contractor's Representative shall provide a full account of the Contract's progress and programme.

(c) The co-ordination and checking of designs, drawings, and submissions. The Contractor's Representative shall be responsible for co-ordinating the design, technical information, and data between Sub-Contractors. All calculations, drawings, and information submitted to the Engineer shall be checked by the Contractor's Representative and certified as having been checked before submission.

(d) Contract communication between the Engineer and the Contractor. The Contractor's Representative shall attend all meetings involving the Contractor and the Engineer.

(e) The coordination and programming of the manufacturer's works tests and the submission of test certificates.

(f) The coordination and programming of Plant delivery.

(g) The coordination and programming of the installation of the Plant on the Site, site tests, and takeover trials. The Contractor's Representative, although not necessarily based at the Site, shall be responsible for the various sub-contractors. At the discretion of the Engineer, regular site meetings will be held during which the Contractor's Representative shall give a full account of site progress and programme.

(h) The Contractor's Representative shall also be responsible for producing in advance of the work being undertaken, detailed method statements of any work that involves or affects the performance of existing equipment, processes, or disruption to existing water supplies.

(i) The coordination, preparation, and submission of As-Built Drawings and Operation and Maintenance Manuals.

(j) Soft copies of all submissions should be in editable form by Word, Excel, PDF, and AutoCAD 2024 or later version.

(k) The preparation and coordination of training of Employer's Personnel.

(l) The submission of applications for payment.

3.7 Meetings

From time to time, the Engineer will call meetings in his office or at the Contractor's office, or at the project Site, as he deems necessary, to discuss progress and any technical points as required.

The Contractor's Representative or designed person above Contractor's Representative shall attend such meetings.

The Contractor shall prepare and submit to the Engineer a daily activity report summarising the main activities undertaken each day. In addition to design and construction issues, safety and environmental management, and the progress of construction are monitored using an S-Curve Chart.

For meetings that are conducted at Engineers office, the Engineer will check the site progress through real time 24/7 CCTV monitoring system installed at project site from the Engineers office. The contractor shall ensure that the location and number of CCTV cameras installed at the project site are sufficient to capture the entire project site and the individual site activity.

Apart from the regular project meetings, the Board may conduct any other high level meeting as needed to ensure the progress of the work at site is as per the approved schedule. Contractor and other project stakeholders shall be informed in advance of such meetings.

3.8 Site Photographs

In accordance with the requirements of the Volume 1 of the Conditions of Contract the Contractor shall supply soft copies of photographs and unmounted positive colour prints not less than 250mm x 200mm

of such portions of the Works, in progress and completed, as may be directed by the Engineer and specified herein. The soft copies and prints shall not be retouched. The soft copy of each photograph shall be the property of the Employer and shall be delivered to the Engineer with the prints. No prints of these soft copies shall be supplied to any other person without the written permission of the Engineer.

The photographs/videos shall be of the following categories:

- Original/Before construction
- Progress Photographs
- Record Photographs
- Real time 24/7 CCTV footage
- Drone Images (Every Month)
- Drone videos (every 3 months)

The above categories shall be properly referenced to the approval of the Engineer, and on the back of each print shall be recorded the date and time of the photograph, the direction in which the camera was facing, an identifying description of the subject, and the reference.

Photographs taken for record purposes as ordered by the Engineer or as specified herein shall be supplied in soft copy and three prints, having the reverse of one superscribed with the signatures of the Contractor and the Engineer (or their authorised representatives) for the purpose of attestation. If required, the Contractor may, at his own expense, have an additional print similarly attested for his retention.

The Contractor shall supply one soft copy and three prints, dated with description of each progress photograph ordered by the Engineer. The Contractor shall supply two additional prints, dated with a description of progress photographs selected by the Engineer for incorporation in albums. The Contractor shall supply two sets of albums, mount the prints, and title the prints and albums, all to the Engineer's approval.

The taking of photographs of the Works by the Contractor for any other purpose, whether for use in India or in any other country, shall not be carried out without written approval from the Engineer.

3.9 A) Setting Out of the Works

The Contractor shall receive the Engineer’s instructions for reference points and elevation points as benchmarks.

The Contractor shall set out the works and carry out the Contractor’s quality control procedures verifying the accuracy and precision of the setting out for each item of the works. The Contractor shall notify the Engineer sufficiently in advance of the setting out to enable the Employer's Representative to observe the accuracy and precision of the laying out. The Engineer's observations shall not relieve the Contractor of responsibility under the Contract for the accuracy and precision of the setting out.

The Engineer shall approve dimensioned drawings, levels, and other information necessary to enable the Contractor to set out the Works, at his own cost. The contractor shall provide all instruments such as theodolite, total station, leveling instruments in good working condition. The contractor shall also provide pegs, ranging rods, long measuring rods, marked meters and decimeters and each meter and decimeter numbered, posts and sight-rails, boning rods, moulds, template etc., together with any

reasonable number of labourers that may be required and set out the Works and be responsible for the accuracy of the same. The Contractor shall amend at his own cost and to the satisfaction of the Engineer any error found at any stage which may arise through inaccurate setting out unless such error is based on incorrect data furnished in writing by the Engineer. The Contractor shall protect and preserve all control points and benchmarks used in setting out the Works till the end of the Defects Liability Period unless the Engineer directs early removal. The Contractor should also keep the theodolite and leveling instruments in good working condition throughout the period of construction work on site.

The checking of any setting out or any line or level by the Engineer shall not in any way relieve the Contractor of his responsibility for the correctness thereof.

No separate payment will be made for setting out the Works as required. Unit rates quoted by the Contractor for all items will be deemed to have covered the expenses for such setting out.

B) Details and Data made available by Employer

The Employer has the following data available and used these in the formulation of the bid elements. They are listed below and shall be used only as guidelines. The Employer does not, however, guarantee either the sufficiency or accuracy of the data provided. Contractor shall carry out a fresh survey, investigation, and particular testing/and all other details necessary for proper planning and detailed design. The Contractor will be required to provide full details of the investigations and analysis for approval by the Engineer.

- Site location
- Access Road
- Boundary

3.10 Engineer's Requirements

The Contractor shall provide the following for use by the Engineer at the proposed WwTP plant sites covered under the contract. These items must be maintained by the Contractor in a proper, safe, and clean working condition throughout the construction period.

No separate payment shall be made for the items covered here.

3.10.1 Engineer's Staff Site Office

A separate office/Porta cabin (temporary in nature) with AC Facility and toilet facilities for the sole use of the Engineer, his staff, and Consultant shall be provided by the Contractor at each WwTP site. The Contractor shall provide, erect, furnish, clean, maintain, and subsequently transfer the office and associated furniture/items to the Employer after the completion of works. The carpet area of the office shall not be less than 50 Sq. Meter.

The location of the office shall be as directed by the Engineer.

The Engineer's staff office shall be ready in all respects within 60 days after the Contractor takes possession of the site. The Office shall be maintained throughout the construction period with office help staff, power, water, sewerage, and housekeeping. These amenities shall be arranged by the Contractor either with the available resources or from independent sources (e.g. diesel generator sets, borewells, etc.) at his own cost.

The Contractor shall furnish the equipment, furniture, furnishings, and fittings supplied shall be new items of approved make.

The equipment, furniture, and furnishings shall include at each WwTPs

(a) 2 Nos. of 3' x 2' table with single side three drawers
(b) 6 Nos Chairs (approved make) excluding for Computers
(c) 1 No. Drawing Cabinet
(d) Filing cabinets, steel with locks and 2 drawers with suspended filing system
(e) Water supply / Plumbing / Electrical complete/Emergency lighting
(f) Other facilities
- 1 No. of PC and 1 No. of Laptop
- 23" SVGA LCD flat panel colour monitor
- 8 USB 2.0 ports, with at least 2 of these in the front, Broadband Internet with 3MBPS Speed
- Internet keyboard
- Optical Mouse and Mouse Pad (two sets)
- Pre-loaded with the latest licensed Operating System compatible with all Engineering Software.
- Comprehensive Security and Management features such as antivirus, antispyware, and firewall.
- HP Colour LaserJet Printer (suitable for A4/A3 size paper) or equivalent
- Additional software – MS Office and AutoCAD (latest version)
- All the necessary consumables, including paper, CDs, printer cartridges, etc. to be provided throughout the contract period.

(g) Fire Extinguisher – CO_2 type (3 Kg) – 1 No.
(h) First Aid
(i) Domestic water

3.10.2 Vehicles

The Contractor shall purchase and maintain one new Bolero or equivalent (ZLX BS IV, A/C) vehicle for the duration of the contract till taking over certificate is issued, to be kept available at all times for the sole use of the Engineer and his staff, at the contractors own cost. The Contractor shall be solely responsible for the upkeep of the vehicle, including taxes, insurance, licenses, fuel, oils, lubricants, repairs, and maintenance, and shall also provide a competent driver, who shall be familiar with Kannada and Hindi Languages. Vehicle shall be handed over to BWSSB in good working condition upon completion of contract.

3.10.3 Electrical Systems

A. <u>Main Electric Supply (Normal 3 Ph 4 wire supply)</u>

a) Main electrical supply shall be received at single point with IP-55 certified 5 Pin welding socket (63Amp) suitable for 415V 50 Hz for distribution of power supply to various appliances.

b) One main incomer distribution board (3 Ph, 4 wire) shall be provided in each cabin with 1 No. RCCB (30 mA sensitivity) along with 63Amps 4 pole MCB and individual MCBs for light, fans and AC. All MCBs shall be housed in metal enclosure.

c) All wiring shall be done with FRLS multistrand PVC insulated copper wire and PVC conduit of concealed type for wiring.

d) The wiring of Air Conditioner (AC) shall be 6 Sq.mm and for lighting/fans shall be 4 Sq.mm.

B. Electrical Fittings

a) LED Battens / Tubes – 4 Nos.
b) 5A Switch & Sockets – 3 Nos.
c) 15A Switch & Sockets – 3 Nos.
d) Emergency LED/CFL Lights with inbuilt battery (2 hrs battery backup) – 2 Nos.
e) Ceiling mounted Fans swing type (12") – 2 Nos.
f) Air-conditioner points with RCCB as per requirement of electricity norms.
g) Split AC of minimum 1.5T with arrangement of condenser unit at one corner inside cabin but open able from outside with locking arrangement.
h) Earthing Arrangements for Panels, DBs, lighting, sockets etc.
i) Projector for meetings.
j) UPS for 1 hour power backup.

3.10.4 Assistance to the Engineer

The Contractor shall provide all necessary assistance to the Engineer and his staff in carrying out their duties of checking, inspecting, and measuring the Works. The Contractor shall provide, at no additional cost, chainmen, staff men, office attendants, and labourers as may be needed from time to time by the Engineer.

The Contractor shall provide the Engineer, his staff, consultants, and their staff, as well as visitors, with protective clothing, safety helmets, and rubber boots of suitable sizes, hand lamps, and other necessary items as may be reasonably required by them. These articles shall remain the property of the Contractor. No extra payment shall be made on this account.

3.10.5 Instruments to be provided

The Contractor shall provide at his own cost for the exclusive use of the staff of the Engineer all survey equipment and measuring instruments of approved make and of every kind necessary for the execution of the Works, including:

(a) Battery operated latest automatic total station with full setup and software/ One 360-degree circle optic theodolite, accurate to one second, complete with carrying case and sliding leg tripod, with an operator shall be in use by the client for the entire construction period.

(b) Two auto levels, tripods with carrying case.

(c) Two levelling staffs, 4.5 m long, each in 3 sections and with attached bubbles, graduated in metres, tenths and hundredths of a metre.

(d) Two surveyor's steel bands, one 100 m long and approximately 20 mm wide, and the other at least 30 m long and approximately 12 mm wide, each fully divided, complete with tape thermometers and tension handles, and wound on an open plastic cross.

(e) An adequate number of ranging rods, steel and linen tapes, string lines, pegs, lines, spirit levels, survey umbrellas, lights, batteries, stores, and tools.

The instruments mentioned above shall be for exclusive use of the Engineer and shall remain in the custody of the Engineer till the Works are completed.

The Contractor shall be solely responsible for all such instruments and equipment and shall ensure that they are in good condition at all times and shall make good any loss or damage howsoever caused. No extra payment shall be made on this account.

3.11 Erection of Plant

The erection of the Plant shall be phased in such a manner as to not obstruct the work being done by other contractors.

Before commencing any erection work, the Contractor shall check the dimensions of structures where the various items of Plant are to be installed and to bring to the Engineer's attention if any deviations from the required positions, lines or dimensions.

The plant shall be erected in a neat and workmanlike manner on the foundations and at the locations shown on the Approved Drawings. Unless otherwise directed by the Engineer, the Contractor shall strictly adhere to the aforementioned drawings.

The Contractor shall be responsible for setting up and erecting the Plant the line and level required and shall ensure that all Plant is securely held and remains in correct alignment before, during, and after grouting-in. This responsibility shall not be passed to any other contractor.

Any damage caused by the Contractor during the course of erection to new or existing plant or building or any part thereto, the Contractor shall, at his own cost, make good, repair or replace the damage, promptly and effectively as approved by the Engineer and to the Engineer's satisfaction.

3.12 Site Labour and Supervision

The Contractor shall provide all skilled and unskilled labour required, as well as all necessary tools and equipment, to erect, test, and commission the Works within the period agreed upon in the programme.

The Contractor shall not remove any supervisory staff or skilled labour from the Site without the Engineer's prior approval.

3.13 Sub-letting

The Contractor shall not sublet the whole of the Works. Where any design or manufacture is sublet, the Contractor shall not be relieved of his obligation under the Contract. The Contractor shall be responsible for the acts, defaults, and neglect of any Sub-Contractor, as if they were their own.

Where the Engineer has consented to the supply of Plant or execution of work by manufacturers or sub-contractors proposed by the Contractor, such manufacturers or sub-contractors shall not be changed without the prior approval in writing of the Engineer.

A copy of every sub-order shall be sent to the Engineer at the time each order is placed clearly marked with the title of the Contract and the Contract number.

3.14 Temporary Works

At least 14 days before commencing any portion of the Works, the Contractor shall submit to the Engineer for approval comprehensive drawings and calculations for all Temporary Works that the Contractor proposes for the construction of that part of the Works.

Notwithstanding approval by the Engineer of any design for the Temporary Works, the Contractor shall be entirely responsible for their safety, efficiency, security, and maintenance and for all obligations and risks in regard to such Temporary Works specified or implied in the Contract.

3.15 Languages

All drawings, instructions, signs, notices, name-plates, etc. for use in the design, construction, operation, and maintenance of the Works shall be in English.

All site sign boards and warning signs shall be in Kannada, Hindi and English Languages.

3.16 Drawings and Information to be provided

3.16.1 General

The drawings that will be prepared and issued for this Contract shall be classified as follows, and where relevant, shall be to a scale which is suitable for the representation of those details illustrated.

The term Drawing shall be deemed to include all drawings, schedules, lists, software documentation, descriptive text, and calculations necessary for the design, construction, operation, and maintenance of the Works and referred to in this clause.

Drawings and all other submittals required during the bidding stage and after the award of the contract shall be submitted in editable electronic softcopy format on CD(s) or DVD(s) as well as in hardcopy paper format. The Contractor shall submit documents in soft copies and eight (8) sets of hard copies to the client for approval.

The softcopy format for various items shall be as follows:

- Drawings: AutoCAD version 2024
- Text Documents: Latest version of Microsoft Word, including Microsoft Project
- Spreadsheets, Hydraulic design/capacity/power calculations, tables, technical schedules, prices schedules, and other numerical data: Latest version of Microsoft Excel.
- All other required information not included in the above shall be in Adobe Portable Document Format (PDF) version 7.x

The hardcopy format/sizes for various items shall be as follows:

- Drawings: Standard A1 size paper. The scale for each drawing shall be selected such that the information is presented without any clutter or ambiguity and is clearly and easily legible without the use of magnifying aids other than a reader’s normal eyeglasses.

- All other information: Standard A4 or A3 paper size, except for any pre-printed standard information such as brochures or catalogue information, which may be submitted in the original size and format.

3.16.2 Drawing Format and Numbering

All drawings shall be prepared using an identical title block format. This shall be approved by the Engineer and shall identify the project, drawing title, the Employer, the Contractor, Sub-contractor, if applicable, and the Engineer.

A formalised drawing numbering system shall be adopted with digits of each number, referencing location, revision, drawing type and size. The Engineer shall approve the numbering format and allocation of drawing number blocks.

The Contractor shall provide a sequential numbering system for all Construction Documents. The drawing number shall not be repeated or duplicated.

All drawings shall be submitted to a formalised checking procedure before submission. Drawings not so checked will not be approved.

3.16.3 Pre-contract Drawings

The Pre-contract Drawings are those issued to Bidders either with the Bidding Documents to illustrate and clarify the Works described in the Employer's Requirements or later during the bidding period as part of an Addendum to the Contract Documents.

Such drawings shall be deemed to have been issued for the guidance of Bidders and shall, to execute the Works, be superseded by the Construction Documents.

3.16.4 Bid Drawings and Details

The Bid Drawings are those furnished by a Bidder with his Bid to illustrate and clarify his proposals.

The following drawings, details, and specific information about the entire sewage treatment process / plant shall be furnished by the Bidder for WwTP / TSPS in the technical envelope in addition to other information mentioned elsewhere in the tender.

The lists provided below shall not be considered comprehensive. The bidder shall be responsible for including all necessary drawings and information for any works that may be required to fully and completely define or clarify the design, regardless of whether such drawings, information, or works are explicitly listed below or elsewhere in these bid documents.

The bid drawings and other technical documents shall be submitted in soft copy format on CD(s) or DVD(s) or pen drive as well as in hardcopy paper format.

(a) General and Process

(i) Narrative Description of the Works.
(ii) Plant Operation and Control Philosophy.

(iii) Sizing and Design Calculations covering all Major Unit Processes and components of the Works.
(iv) List of all structures (basins, tanks, channels, buildings, etc.), including dimensions and freeboards.
(v) Complete Equipment List.
(vi) Plant Layout.
(vii) Hydraulic Profile.
(viii) Process Flow Diagram.
(ix) Process and Instrumentation Diagrams (P&IDs)
(x) Electrical Load List & Power Consumption Chart.
(xi) List of Chemical Consumption on Daily/ Monthly Basis.

(b) Mechanical

(i) To-scale dimensional layout and/or installation drawings for **ALL** relevant Equipment that is suggested by the Contractor. For instance, in case of an SBR plant with digesters and biogas, the following may be the minimum requirement for drawings:

- Raw Sewage Pump sets
- Coarse and Fine screens
- Vortex Grit Chamber
- RAS/WAS Pumps
- Submersible Mixers
- SBR Decanter
- Fine Bubble Diffusers (fixed)
- Disc Filtration System
- Chlorination system
- Decanter Centrifuge
- Other equipment

(ii) Graphs for all major pumps and blowers (including but not limited to Raw Sewage Pumps, Primary Sludge Pumps, Return Activated Sludge Pumps, Mixed Liquor Recycle Pumps, Thickened Sludge Pumps, Centrifuge Feed Pumps, Process Air Blowers, Pump Performance Curves: Q vs H, speed, P, Efficiency, and NPSH.

(iii) Efficiency curves of the pump model proposed

(c) Electrical & Instrumentation

(i) Electrical Single Line Diagram.
(ii) Sizing Calculations for Transformers and DG Set.
(iii) Specific Energy Consumption.
(iv) Technical Schedules for Electrical Works, duly filled in.
(v) Instrumentation SCADA.

(d) Construction schedule.

3.16.5 Drawings and Calculations to be submitted by the Contractor for Approval

Drawings / Calculations for approval shall be submitted by the selected Contractor after award of the contract in two Stages.
The first phase shall be the Preliminary Drawings / Designs. Drawings /Designs submitted during this phase shall be of sufficient detail for the Employer and Engineer to understand in outline the Contractor's proposals for the design and construction of the Works.

The Preliminary Drawings / Designs for WwTP with associated pumping main shall inter alia comprise:

- Detailed Description of the proposed Wastewater Treatment Plant and treatment process, including Raw and treated sewage quality.
- Detailed Plant Operation and Control Philosophy.
- Detailed process design calculations and mass balance calculations covering all Units/Equipment.
- Detailed List of Units including Unit Dimensions/ Free Boards.
- Detailed Equipment List.
- Major Equipment /Instrument Specifications (with supporting Brochures).
- Major Piping Schedule to include size, material, coating, lining, gauges/thickness, and pressure rating.
- Major Valve Schedule to include size, type, material, pressure rating, operator/actuator type, and whether Open/Close or Modulating.
- Gate Schedule to include size, type, differential head, seating or unseating, operator/actuator type, and whether Open/Close or Modulating.
- Detailed Plant Layout (including Pipe Sizes/ Pipe Routing/ Channel Size/ Channel Routing/ Site Roads/ Site Drainage/each processing facilities).
- Detailed Hydraulic Profile including Hydraulic Calculations.
- Detailed Process Flow Diagram (inclusive of Mass Balance).
- Process and Instrumentation Diagram (P&ID) and SCADA.
- Detailed Chemical Consumption Calculations (Daily/ Monthly Basis).
- Transformer sizing calculation for WwTP based on approved Electrical load list.
- D.G sizing calculation for WwTP based on approved Electrical load list.
- Full Hazardous Area Classification Analysis and Report per IS 5572 for WwTP in the contract.
- Hazardous Area Classification Drawings per IS 5572 for WwTP in the contract.
- Design Concept Report for Electrical Equipment including total power consumption.

The second stage shall be the Detailed Engineering Design phase and shall comprise the submission of the Detailed Mechanical/ Electrical/ Instrumentation/ SCADA/ Structural/ Civil Construction Drawings and Calculations. These shall be submitted after the approval of the Preliminary Drawings. The lists provided below shall not be considered comprehensive. The bidder shall be responsible for including any and all drawings and information for any and all works that may be necessary for full and complete definition or clarification of the design, regardless of whether or not such drawings, information, or works are explicitly included in the lists below or elsewhere in these bid documents.

The Construction Documents shall be used for the construction of the Works and shall inter alia comprise:

(a) Civil

Site layouts for WwTPs providing information on levels and detailing the location of:

- General arrangements and main sections of all plant areas.
- Plans, elevations, and main sections of all structures and buildings.
- Buildings.
- Storage tanks.
- Process plants.
- Transformer enclosures.
- Roadways.
- Drainage (plant drainage, sanitation, and storm water drainage).
- Buried pipelines.
- Cable routes for direct in-ground and ducted systems.

Detail drawings of:

- Cable and pipework chambers.
- Buried pipework.
- Pipework connections.
- Contract interface.
- Reinforcement drawings.
- Bar bending schedules.

Calculations for:

- Detailed Structural Design calculation of all the units/ Structures

(b) Hydraulic

-Detailed hydraulic profile (WwTP / TSPS).
-Detailed hydraulic calculations (WwTP / TSPS).
-Plan and L-Section profile of Pumping Main.

(c) Process

Drawings:

-Process flow diagram.
-Comprehensive P&ID s including details of.
-Pipeline sizes and materials.
-Valve size and type.
-Equipment detail.
-Instrumentation.
-Identification of the controlling PLC.

Calculations for:

-Detailed Process Design Calculations / Mass Balance Calculations covering all Units/ Equipment.
-Detailed List of Units including Unit Dimensions/ Free Boards.
-Detailed Equipment List.
-Major Equipment /Instrument Specifications (with supporting Brochures).

-Major Piping Schedule to include size, material, coating, lining, gauges/thickness, and pressure rating.
-Major Valve Schedule to include size, type, material, pressure rating, operator/actuator type, and whether Open/Close or Modulating.
-Gate Schedule to include size, type, differential head, seating or unseating, operator/actuator type, and whether Open/Close or Modulating.
-Detailed Process Flow Diagram (inclusive of Mass Balance).
-Detailed Electrical Power Consumption Calculations.
-Detailed Chemical Consumption Calculations (Daily/ Monthly Basis).

(d) Mechanical

Drawings:

Outline dimensional drawing & Cross section Drawing (with Bill of Quantity and Material of construction) for the following items for WwTPs, but not limited to:

1.	Raw Sewage Pumpset
2.	TSPS Coarse screens
3.	Medium screens
4.	Screw Conveyor for screenings
5.	Sluice valve – motorised
6.	Sluice valve – manually operated
7.	Non-Return valves
8.	Knife Gate Valves
9.	Dismantling joints
10.	H.O.T & E.O.T Cranes
11.	Sluice gate – Manual & Motorised
12.	Dewatering Pumpset
13.	Grit removal equipment/Grit washing equipment
14.	Fine Bubble Diffused Aerators along with Grid
15.	Process Air Blowers
16.	Decanters
17.	Return activated sludge and Waste activated sludge Pumpset
18.	Chlorination system
19.	Alum dosing system
20.	Chlorination system
21.	Plant Drain Pumps
22.	Plant Water Pumps
23.	Sludge Dewatering Centrifuges
24.	Chemical Dosing Pumps and Agitators
25.	Sludge belt conveyor system & Hopper
26.	Sludge Dewatering Centrifuge, Feed Pumps, other equipment.
Graphs for all major pumps and blowers (including but not limited to Raw Sewage Pumps, Primary Sludge Pumps, Return Activated Sludge Pumps, Mixed Liquor Recycle Pumps, Thickened Sludge Pumps, Centrifuge Feed Pumps, Process Air Blowers) Pump Performance Curves : vs H, speed, P, Efficiency, and NPSH Efficiency curves of the pump model proposed	

(e) Electrical

Drawings:

(1) Detailed Electrical Load List for all WwTP/TSPS prepared based on the approved Equipment list from process and Mechanical.
(2) Transformer sizing calculation for all the WwTP/TSPS based on the approved Electrical load list.
(3) D.G sizing calculation for all WwTP/TSPS based on the approved Electrical load list.
(4) Key & Protection Single Line Diagram of Complete Electrical System for WwTP/TSPS based on the equipment finalized by Mechanical and Process, along with operating logic.
(5) Electrical Substation Layout / MCC room layout of WwTP/TSPS showing Panel locations, Transformer locations and Trench Layout.
(6) 11kV Switchgears:
    (a) Single Line Diagram, Control schematic diagrams to cover controls, protection, interlocks, switches, instruments, space heaters, etc. for each type of module.
    (b) Itemised bill of materials for each module, listing all devices mounted and any other items furnished, such as cable glands, indicating the type, rating, quantity, and any special notes.
    (c) Detailed internal wiring diagram of each type of module, including terminal block number, ferrule numbers and the external cable connection designations.
    (d) Inter-panel interconnection wiring diagram, including terminal numbers and ferrule numbers.
    (e) Busbar sizing and CT, PT sizing calculation, Heat loads calculations, Thermal withstand calculations
    (f) Panel footprint drawing showing overall dimensions, plan, elevation, typical sectional views, details of busbar and cable entry, mounting arrangement, and cable cut-out details.
    (g) Guaranteed Technical Particulars.
    (h) Foundation plan showing the location of channel sills, anchor bolts and anchors, floor plans and openings.

(7) Diesel Generator Set
    (a) Guaranteed Technical Particulars.
    (b) Busbar sizing calculations
    (c) GA Drawing showing overall dimensions, plan, elevation, sectional views, mounting arrangement, layout, make, type, rating, etc. of diesel engine, Alternator, Control panel, battery, battery charger, etc.
    (d) Single Line & Schematic diagrams showing details of Power & Control, AMF details, interlocks, protections, annunciations, battery, battery charger etc with make, type, rating, setting etc of various equipment, components etc.
    (e) Foundation plan showing the location of channel sills, foundation, anchor bolts and anchors, floor plans and openings.
    (f) Exhaust system with piping layout.
    (g) Day oil tank sizing with mounting and piping arrangement details.

(8) 11/ 433 kV Transformers
    (a) Guaranteed Technical Particulars.

(b) Efficiency calculations, Radiator sizing, heat load calculations.
(c) General arrangement drawing of the transformer, showing plan, front elevation, and side elevation, complete with all accessories and fittings, detailed dimensions, net weights, quantity of oil, clearances between HV terminals, between LV terminals, between HV and LV terminals, between HV & LV terminals, and ground, etc.
(d) Rating, diagram, and terminal marking, complete with polarity and vector group.
(e) Foundation drawing with position of foundation bolts and depth.
(f) OLTC/RTCC: GA drawings, schematic circuit diagram and actual detailed wiring diagram giving terminal numbers (if applicable)
(g) Marshalling box: GA drawing, terminal connections wiring diagram, cable boxes.
(h) Disconnecting chambers
(i) Bushings
(j) LT bus duct flange (if applicable)

(9) L.T Panels, Distribution Boards, Power Control Centres, Power Motor Control Centres, Motor Control Centres, Distribution Boards etc.
(a) Guaranteed Technical Particulars.
(b) Busbar sizing calculations.
(c) Dimensional Drawing showing overall dimensions, plan, elevation, and cable entry details.
(d) Complete assembly drawings of the switchboard/distribution board / MCC showing plan, elevation and typical sectional, views, details of busbars and location of power &control cable terminal blocks for external wiring connections, etc.
(e) Foundation plan showing the location of channel sills, anchor bolts and anchors, floor plans and openings.
(f) Single Line Diagram &Schematic power and control wiring diagrams along with details, complete bill of materials indicating make, type, rating, setting, etc of Circuit breakers, relays, contactors, current transformers, potential transformers, instruments, meters, annunciations, etc .
(g) Feeder Operation and Interlock logic.

(10) L.T Capacitor bank with Automatic Power Factor Correction Relay
(a) Guaranteed Technical Particulars.
(b) Busbar sizing calculations
(c) Fully dimensioned general arrangement drawings of the capacitor and the capacitor control panel with elevation, side view, sectional view, and foundation details.
(d) Justification for the number of steps for switching.
(e) Single Line Diagram, Schematic, and wiring diagrams for the capacitor control panel, complete with bill of materials.

(11) Variable Frequency Drives
(a) Guaranteed Technical Particulars.
(b) Dimensional details with mounting arrangement.

(c) Single Line Diagram and Schematic power and control wiring diagrams, along with details, a complete bill of materials indicating the make, type, rating, and setting of various equipment/components/items.
(d) Specific details of converter, inverter and harmonic control units.

(12) Battery and Battery Charger with D.C. Distribution board
(a) Guaranteed Technical Particulars
(b) Battery, Battery Charger & interconnecting Cable Sizing Calculations.
(c) Dimensioned general arrangement drawings.
(d) Fully dimensioned general arrangement drawings of battery and battery charger & DCDB with elevation, side view, and sectional view and foundation details.
(e) Single-line diagram, complete schematic, block diagram, and wiring diagrams with a bill of materials.
(f) Operational write-up and manufacturer data sheets, curves, etc.

(13) Non Segregated LT Bus duct
(a) Guaranteed Technical Particulars.
(b) Dimensioned general arrangement drawings.
(c) Layout drawings with bill of materials.

(14) Cabling System
(a) Guaranteed Technical Particulars of HT & LT Power and Control Cables.
(b) Details of Installation of Cables in Trenches, on cable trays, directly buried etc at all locations inside the plant.
(c) Cable routing plan and section inside the plant.
(d) 11kV Cable termination and mounting kit layout drawing.
(e) Datasheets for various cables.

(15) Lighting system
(a) Make, type, rating, etc of various fixtures, receptacles, switches, etc. in various premises.
(b) Make, type, rating, etc. of various fixtures, lighting poles, etc for street lighting and flood lighting.
(c) Detailed room-wise Lighting Layout with Type of fixture details and Circuit diagram showing phase-wise load distribution and interconnection between switches, fixtures, Lighting panel, receptacles, etc.
(d) Internal road Lighting and Area lighting layout with location of poles, details of fixtures and mounting.
(e) Street Light pole details with Foundation details.

(16) Earthing System and lightning Protection

(a) Details such as material, sizes, etc. of the earth conductor and electrode pits.
(b) Overall Plant Earthing & Lightning Protection Layout
(c) Earthing layout drawing showing the routing of the main grid inside the plant, with details of the interconnection of equipment earthing to the grid and earth pits.
(d) Detailed room-wise earthing Layout with Type of earth conductors, routing, typical connection details, Bill of materials, etc.

(e) Building Lightning Protection Layouts

(17) Electrical Equipment and Panel Layout/MCC room layouts
(18) Indoor & Outdoor Lighting Layout.
(19) Indoor and Outdoor Cable Trench, Cable Tray, and Cable Layout.

Schedules

(1) Cable schedules & bill of quantities.
(2) Electrical Load and Power consumption schedule.
(3) Protection relay setting schedule.

Calculations

(1) Specific Energy Consumption Calculations.
(2) Bus bar sizing calculation for 11 kV Switchgears, 415V Switchgears etc.
(3) Co-ordinated protection study as per IS 13234.
(4) Fault level and Voltage Dip Calculations as per IS 13234.
(5) Hormonic Analysis study for VFDs.
(6) Arc Flash Study as per IEEE 1584.
(7) Sizing of Capacitor banks.
(8) Sizing Calculation for Battery and Battery Charger.
(9) Non-Segregated Bus Duct.
   (a) Sizing of the bus bars vis-à-vis thermal capability to withstand the rated Continuous current and one-second short-time current.
   (b) Spacing of the insulators in relation to their mechanical strength to withstand forces due to momentary short-circuit current.
   (c) Heat loss and temperature rise calculations for conductor and enclosure. All formulae and other information from which the heat losses have been derived shall be listed.
(10) HT and LT Cable sizing.
(11) Earthing system calculation
(12) Room-wise Lighting Calculation as per the Lux level given in the specification.
(13) Outdoor Lighting Calculation / Street Lighting / Area Lighting calculation
(14) Lightning protection risk assessment, Building Lightning Protection and Lightning conductor sizing Calculation.

(f) Instrumentation and Control

Drawings:

- Power supply distribution single-line diagrams and schematics (see note 1) for each control panel.
- Internal and external (see note 2) general arrangement for each control panel (dimensional).
- Control panel wiring diagram, relay logic diagram, and terminal block details.
- System configuration including communication with, remote monitoring from central SCADA stations.
- And layout diagram along with bill of material, program listings, block logic diagram, and control logic write-up for PLC.
- UPS and battery sizing calculations.
- Control and instrumentation loop drawings (see note 3).
- Instrument installation detail drawing (hook-up, see Note 4).
- Cable block diagrams.
- Cable routing/installation drawings.

- Foundation and fixing details and trenches drawings.
- Mimic general arrangement (full colour copies shall be provided).

Schedules:
- Cable schedule.
- Cable interconnection schedule.
- Control and instrumentation load schedule for each control panel.
- I /O schedule.
- Junction box schedule.
- Instrument schedule with make, model &tag nos.
- Instrumentation, process control set point schedule.
- Instrument data sheets.
- Spares Summary.

Documentation:
- Document Control Index.
- Functional design specification (FDS).
- Bill of Materials Database.
- Factory Acceptance Test (FAT) document.
- Site Acceptance Test (SAT) document.
- As-built documentation.

Notes:
1. Schematic drawings shall include a comprehensive schedule of the components used in each switchboard, MCC, and control panel, including details of the type, manufacturer, and rating of each component.
2. The external arrangement of each switchboard, MCC, and control panel shall show the arrangement of all components, including details of panel section, switch, and instrument labels.
3. Control and instrumentation loop drawings shall show on a single drawing the complete circuit associated with an instrument or device, including details and location of power supplies, cabling, and terminations.
4. Hook-up drawings shall detail the installation of an instrument or device.

Instrumentation, Electrical control schematics, loop diagrams, and schedules shall, where practical, be A3 size drawings; all other drawings shall be A1 size.

(g) Mechanical Building Services

Drawings:
- Single line schematics for the wastewater system and drainage systems
- General arrangement drawings showing the location of each mechanical building service plant item
- General arrangement of ventilation systems
- Fixing details.

Schedule:
- Plant data sheets with Equipment GA dimensional drawing, Foundation detail, Calculation, and manufacturer’s quality assurance plan.
- Pipeline schedules.
- Valve schedules.

Calculations for:
- System & Equipment sizing.

The Engineer reserves the right to request additional Equipment/system information beyond the above to ensure a well-designed system and proper equipment selection.

3.16.6 Balanced Project Progress

The procurement and delivery of electro-mechanical equipment shall be planned in coordination with the progress of civil construction to ensure seamless project execution. The contractor shall ensure that civil works reach a substantial completion milestone before delivering electro-mechanical equipment to the site, preventing premature storage and ensuring efficient installation. Procurement schedules should be synchronized with the overall project timeline to maintain a balanced representation of the progress. The Engineer shall conduct regular progress reviews and inspections to verify alignment between civil works and the delivery schedule of electro-mechanical equipment, ensuring smooth integration into the project.

The contractor shall adhere strictly to the technical requirements outlined in the tender document, ensuring full compliance with the specified requirements. Procurement activities shall be carefully planned in alignment with the project timeline to avoid delays. Having thoroughly reviewed the technical requirements, the contractor shall ensure the timely procurement and delivery of equipments to the site. Additionally, the contractor shall ensure that a single equipment package is not split among multiple vendors, as this could lead to coordination issues or performance discrepancies.

While unforeseen challenges may arise, proactive management of procurement and execution is essential to maintaining project progress. Instead of submitting an undertaking letter to justify technical deviations or procurement delays, any such procurement-related concerns should be identified and addressed transparently at an early stage to ensure timely resolution while maintaining full compliance with the technical requirements defined in the tender document.

3.16.7 Mandatory Reports

As part of the execution of the proposed works, the contractor is required to submit a comprehensive set of documents at various stages of the project as defined. Also, the following documents are essential for submission to ensure compliance with the specifications as detailed in Volume 2 & Volume 3 of the tender document, to facilitate efficient designs, effective monitoring, control, and execution of the project. The list of the mandatory reports that need to be submitted shall be as follows:

- Monthly Environmental Monitoring Reports
- Monthly Project Progress Reports
- Surge Analysis of Pumping Mains
- Report on Site Survey Works of the Plant
- Report on Site Geotechnical Investigation Works of the Plant
- Concept Design Report on Plant Process
- Concept Design Report on Plant Hydraulics
- Concept Design Report on Plant Power Generation.
- Concept Design Report on Civil Works of the Plant
- Concept Design Report on Structural Design Works of the Plant

- Concept Design Report on Mechanical Works of the Plant
- Concept Design Report on Electrical Works of the Plant
- Concept Design Report on Instrumentation Works of the Plant
- Concept Design Report on Control and Automation Works of the Plant
- Report on Architectural Works of the Buildings of the Plant
- Fault Level Calculations and Load Flow Studies
- Energy Optimization Plan
- FAT Reports
- SAT Reports
- Report on Plant Laboratory Setup
- Implementation Report on Cyber Security
- Operation & Maintenance Manuals
- Training Programme and Manuals

In summary, the contractor is mandated to furnish these reports to ensure a comprehensive and systematic approach to the design, execution, and operation of the proposed works. Each report plays a pivotal role in maintaining high standards of safety, quality, and efficiency, thereby contributing to the successful completion and operation of the project.

3.16.8 Good for Construction

In order to maintain the quality and accuracy in Good for Construction (GFC) documentation, this tender document implements the eligibility criteria for the approval of all documents and drawings for GFC.

These criteria are designed to ensure that only error-free documents proceed to the construction phase with approval status B or A, while other document status (C and D) are returned to the contractor for resubmission to obtain approval status B or A. This engineered approach minimizes potential issues during the construction phase and avoids unnecessary time delays.

Status		Details
A	:	Approved, manufacture / construction may commence.
B	:	Acceptable subject to changes indicated, resubmit for approval but manufacture / construction may commence.
C	:	Amend as comments indicated and resubmit for approval.
D	:	Comments noted in letter / memo attached to forwarding transmittal No……., Dated……., amend as comments indicated and resubmit for approval.
E	:	Amend as comments indicated and resubmit for record.
G	:	Comments noted in letter / memo attached to forwarding transmittal No……., Dated……., amend as comments indicated and resubmit for record.
F	:	Drawing / Document of this category is for information only, and not required to be approved.
H	:	Returned without Review.

3.16.9 As-Built Drawings

These drawings shall be compiled by the Contractor and shall constitute a permanent record of the Works as executed. These shall include all such drawings, schedules, documentation, and calculations as necessary for a complete understanding of the Works design, operation, and maintenance.

The As-Built Drawings shall consist of the fully updated versions of the approved Construction Documents incorporating any additional information which will assist the Employer in operating, maintaining, and if necessary, modifying or extending the Works at a later date. These drawings should extend and supplement the information given in the Operating and Maintenance Manuals.

A3 and smaller-sized As-Built Drawings shall be provided on durable paper for reproduction by photocopier. As-built drawings larger than A3 size shall be provided as a paper copy and also produced in the form of black lines on a durable, translucent film, from which further paper prints can be taken by others as required. In addition, drawings shall be provided as an AutoCAD (latest revision) software copy in editable form on a Compact Disc (CD) in two sets.

Text shall be provided in an industry standard word processing, spreadsheet or database format as appropriate (Editable copy).

3.17 Operating and Maintenance Manuals

3.17.1 General

The Contractor shall compile operating, maintenance and overhauling instructions for the whole of the Plant.

The instructions shall consist of one volume of:

(a) General descriptive text (including drawings for illustration) of the Works described section by section.

(b) Complete operational instructions for the sewage treatment plant. This shall be referred to as the Operator's Manual. It shall be aimed at the operational staff and shall be written in clear, unambiguous text, complete with drawings that are necessary for clarification of any issues. The manual shall comprehensively detail what to do on a day-to-day basis and also what to do in the event of faults developing. It shall, in addition, provide a complete list of the process maintenance tasks the operator should carry out, including the intervals between these tasks.

(c) Essential instructions for mechanical and electrical maintenance of the Plant. These instructions shall be concise and set out in a consolidated schedule, outlining the inspection, lubrication, cleaning, and any other type of servicing operations required. The Contractor shall prepare typical maintenance log sheets that the Employer can subsequently use for daily, weekly, monthly, or other periodic maintenance and shall maintain records of plant maintenance operations.

(d) Instructions for use of skilled maintenance personnel in fault location, carrying out routine replacements, withdrawing, dismantling, overhauling, reassembling, and testing the various items of Plant.

(e) Manufacturer's Technical Documentation subdivided into categories for:
- Civil.
- Process.
- Measurement against Inflow load fluctuations.
- Deterioration of treated water due to bulking.
- Other troubleshooting.
- Managing the Index for process operations.
- Electrical.
- Electrical building services.
- Mechanical building services.
- Instrumentation and control.

(f) Civil As-Built Drawings.

(g) Comprising the FDS and PLC code.

(h) Electrical As-Built Drawings: The electrical drawings shall be complete sets, including all necessary information for maintenance and spare replacement.

(i) Control and instrumentation As-Built Drawings: The drawings shall be complete sets including all information necessary for maintenance and spares replacement.

(j) Mechanical As-Built Drawings: The mechanical drawings shall be complete sets including all information necessary for maintenance and spares replacement.

(k) Electrical and mechanical building services As-Built Drawings: The drawings shall be complete sets including all information necessary for maintenance and spares replacement.

(l) FAT records for the Plants and Works.

(m) SAT records for the Plants and Works.

Each volume shall be subdivided (relating to areas of plant) into sub sections or sub-volumes in order to ease the location of plant details. Each volume or sub volume shall be provided with a comprehensive index for the volume or sub-volume concerned and the O & M manual as a whole.

Each volume shall be enclosed within A4 and A3 ring binders having tough grease resistant covers suitable for use on site and designed to permit the easy removal and insertion of the contents. The front cover and spine of each volume shall show details of the project, the Employer, the Engineer, and the volume title.

Text shall generally be enclosed in A4 ring binders, A3 drawings shall be enclosed within A3 ring binders except where they accompany A4 text, in which case they shall be folded. A1 drawings shall generally be folded and enclosed in A4 box files. Where A1 drawings accompany text, they shall be folded and enclosed in an A4 plastic wallet, one wallet per drawing.

3.18 Submission of Documents and Drawings

The Contractor shall supply to the Engineer 3 (Three) copies each (Hard copy & Soft copy) of the drawings and design calculations for the process and sizing of all components of the System including architectural, structural, mechanical, electrical and instrumentation equipment, supported by flow diagrams and general arrangement drawings for approval.

The Engineer may require the Contractor to submit additional drawings for approval if necessary to ensure that the items are well-designed, comply with the Employer's requirements, and are suitable for their intended purpose. These drawings shall form the agreed basis for the execution of the Works. If an approved drawing is revised, revised copies shall be submitted for approval as above, and no such

revised drawing shall be used for the purposes of the Contract until it has been approved in place of the earlier issue of the drawing.

The Employer shall arrange to send observations if necessary, within 28 (twenty eight) calendar days of submission of the design and drawings for modifications to the Contractor. The Contractor shall incorporate all necessary comments from the Engineer into the above design and drawings, if any, and shall resubmit three (3) additional copies, each in both hard copy and soft copy, of the revised designs and drawings within ten (10) days for final approval by the Engineer. The Contractor shall thereafter submit eight (8) copies each of the approved designs and eight (8) copies each of the approved drawings, together with one copy each of the reproducible tracings. The Engineer will return 2 (two) approved copies to the Contractor and retain 6 (six) for the Engineer's office and field use.

Review of all types of documents & drawings for all revisions (R0, R1, R2……)	:	3 (Three) copies
As approved B-Code and A-Code)	:	8 (Eight) copies
As approved As Built Documents & Drawings)	:	8 (Eight) copies
As approved (Any Documents & Drawings as required)		8 (Eight) copies
As approved (O&M Manual)	:	15 (Fifteen) copies

If the submissions require more than one round of revision on account of incomplete compliance from the Contractor, the delay will be on account of the Contractor. If new observations are given by the Engineer, the Contractor will be entitled to take an additional 10 (ten) days for compliance.

The Engineer will signify his approval or disapproval of the Preliminary Phase Drawings / Construction Documents within 28 (twenty-eight) calendar days of each submission.

The structural designs shall be submitted along with STAAD files (input and output).

The Construction Documents are certified Drawings submitted by the Contractor to the Employer or Engineer during the course of the Contract for approval. Construction Documents shall be submitted in accordance with the timetable set down in the Work Programme.

Approval of drawings by the Engineer shall not be construed as relieving the Contractor of their responsibilities under the Contract.

The construction drawings shall be submitted in A1-sized drawing papers and to a readable scale.

The Engineer will not permit construction to start on a part or section of the Works unless Construction Documents for that part or section have been approved.

Draft copies of the O & M Manuals shall be submitted to the Engineer for his approval at least 56 (fifty six) calendar days prior to the commencement of Tests on Completion.

The Engineer will signify his approval or disapproval of the O & M Manuals within 28 (twenty eight) calendar days of submission.

Draft As-Built Drawings shall be submitted 56 calendar days before the commencement of Tests on Completion.

The Engineer will signify his approval or disapproval of the As-Built Drawings within 28 (twenty eight) calendar days of submission.

The Final As-Built Drawings shall be submitted prior to the issue of any Taking Over Certificate.

To remove doubt the submission dates referred to above shall be the dates on which the drawings and documents are received by the Engineer.

3.19 Notice of Operations

The Contractor shall provide the Engineer with full and complete written notice of all important operations sufficiently in advance to enable the Engineer to make necessary arrangements for inspection and any other purpose. The Contractor shall not start any important operation without the written approval of the Engineer.

3.20 Protection of Existing Installations

The Contractor shall submit a written application to the Engineer at least 28 days prior to commencing any work that involves interference with existing structures, equipment, or other facilities. The Contractor shall not execute such work until he has received permission to proceed, in writing, from the Engineer.

The Contractor shall ensure that no earth, debris, or rock is deposited on public or private roads or rights of way as a result of the Works, and all vehicles leaving the Site shall be cleaned accordingly.

3.21 Protection of Existing Public and Private Services

The Contractor shall notify all public authorities, utility companies, and private owners of proposed works that will affect them at least two weeks before commencing the works.

The Contractor shall adequately protect, uphold, maintain, and prevent damage to all services and shall not interfere with their operation without the prior consent of the public authorities, utility companies, private owners, or the Engineer as appropriate.

If any damage to services results from the execution of the Works, the Contractor shall immediately:

(a) Notify the Engineer and appropriate public authority, utility company, or private owner.

(b) Make arrangements for the damage to be made good without delay, to the satisfaction of the relevant public authorities, utility company, or private owner, as appropriate. The Contractor shall be liable for all costs for making good such damage.

The Engineer may issue instructions or make other such arrangements as he deems necessary to repair rapidly any essential services damaged during the execution of the Contract. Such arrangements shall not affect any liability to pay for making good the damage.

3.22 Reinstatement and Compensation for Damage to Persons or Property

The Contractor shall reinstate all properties, whether public or private that are damaged in consequence of the construction and maintenance of the Works to a condition as specified and at least equal to that which existed before their first entry.

If in the opinion of the Engineer the Contractor shall have failed to take reasonable and prompt action to discharge his obligations in the matter of reinstatement, the Engineer will inform the Contractor in writing of his opinion, in which circumstances the Employer reserves the right to employ others to do the necessary work of reinstatement and to deduct the cost thereof as certified by the Engineer from any money due or which shall become due from the Employer to the Contractor.

The Contractor shall refer to the Employer without delay all claims, which may be considered to fall within the exceptions listed in the Conditions of Contract.

3.23 Packing and Protection

Before any Plant is dispatched from a manufacturer's factory, it shall be adequately protected and packed to ensure that it will arrive on the Site in an undamaged condition. The methods employed for protection and packing must be suitable for withstanding the conditions which may be experienced during shipment, delivery to the Site, and prolonged periods of storage in the open, whether the items are shipped in packing cases, crates, or only partially protected according to their nature.

Bright parts and bearing surfaces shall be protected from corrosion by applying a rust preventive lacquer, high-melting-point grease, or similar temporary protection. A sufficient quantity of solvent shall be supplied with the plant to enable the coating to be removed on-site.

All machined flanges and other mating surfaces shall be protected by means of wood templates. The bolts for securing these templates shall not be reused in the final installation.

No one crate or package shall contain items of Plant intended for incorporation in more than one part of the Works.

All items of Plant shall be clearly marked for identification against the packing list, which shall be placed in a waterproof envelope inside every packing case or crate.

Every packing case and crate shall be indelibly marked to show its weight, serial number, top and bottom, shipping marks and handling instructions or sling marks.

Electrical Plant shall be enclosed in sealed airtight packages with dehydrating material, before being placed in packing cases on shock-absorbent material and secured by means of battens.

3.24 Quality Assurance

3.24.1 Policy

In accordance with Clause 4.9 of the Conditions of the Contract, the Contractor shall apply the formal requirements of Quality Assurance to the design, supply, construction, and maintenance of the Works. This shall be achieved through the implementation of a Quality System compliant with the requirements of BS 5750 or an equivalent International Standard.
A positive commitment to Quality Assurance shall be expressed in a formal policy statement included in the Contractor's Quality Manual.

3.24.2 Objectives

It shall be the stated aim of the Contractor to achieve and demonstrate the achievement of quality as expressed by `due care and diligence' of the design, supply, construction and maintenance of the Works as defined by the Employer's Requirements.
The criteria to define `due care and diligence' shall be explained in the Contractor's Quality Plan and shall embody all of the design, supply, construction, and maintenance requirements of the Works.

3.24.3 Quality System

The Quality System shall be fully integrated for all works.

This system will be defined by the organisational structure, responsibilities, activities, resources, and events that, together, demonstrate the Contractor's capability to meet the stated quality requirements.

The Contractor shall ensure that all Sub-Contractors and sub-consultants establish quality systems and supply the Employer with such evidence as is necessary to demonstrate the effective implementation of a quality system in each Sub-Contractor or sub-consultant organisation.

The Quality System of the Contractor, their Sub-Contractor, and sub-consultants will be subject to periodic audits undertaken by the Engineer. The Engineer will give two weeks' notice of such audits that will involve a full assessment of the performance and efficiency of the Quality System and will include review of the feedback and records derived from the Contractor's monitoring and internal reviews.

On a day-to-day basis the Contractor shall afford reasonable availability of staff and documentation for the Engineer to assess the implementation of the Quality System. The Contractor shall ensure that all relevant personnel and documentation are available for such audits.

3.24.4 Quality Plan

The implementation of the Quality System shall be through the establishment of a comprehensive Quality Plan issued to and approved by the Engineer.

The documented procedures shall include, but not be limited to:

- Management Procedures.
- Design.
- Supply/Procurement.
- Construction.
- Putting to work/Commissioning/Reliability Trial/Performance Test, witnessing the test and review.
- Operator Training and Maintenance.
- Interface Control.
- Quality Performance, Monitoring and Review.

There shall be procedures to control transmission of information across all interfaces both internally (that is, within the Contractor's Quality System) and externally. Those of the latter shall include all Statutory Bodies, Authorities and the Engineer.

Formal assessment of any non-compliance with the Quality Plan shall be achieved through periodic reviews undertaken by a team appointed by the Contractor. All deficiencies shall be recorded and appropriate corrective measures shall be assessed, within an appropriate timescale, through subsequent formal reviews undertaken by the Contractor.

3.24.5 Quality Feedback

The system shall include for the reporting back, recording and incorporation into the system of deficiencies and remedial measures to correct them noted during the control of the project.

3.25 Environmental Protection

The Contractor shall minimize, as far as is practically possible, the effects of all his and his Subcontractor's activities upon the environment and shall implement and monitor measures to prevent:

(a) Contamination of surfaces, ground, groundwater, surface water, and rivers.
(b) Emissions to air, including smells, gases, smoke, and dust.
(c) Unsanitary or unsafe storage or discharge to drain, sewer and surface waters.
(d) Unsanitary or unsafe storage or disposal of solid waste.
(e) Noise.
(f) Visual intrusion, and
(g) Excessive energy and water consumption.

These requirements shall be met through the constant and careful attention of the Contractor's management to all Site and off-site activities, and by instructing all staff and labor in these matters.

The Contractor shall appoint an Environmental Control Manager for the Works, who shall be responsible for preparing an Environmental Management Plan and ensuring its implementation by the Contractor after obtaining the Engineer's approval.

Implementation shall include monitoring and reporting on the results of the above measures. Monitoring reports shall be submitted in writing every month as part of the monthly report referred to above. The report shall include a listing and summary of daily monitoring results on all aspects listed above.

All potentially affected areas of the Site, other areas used for or affected by the works, and all adjacent or affected waterways shall be monitored and, where instructed by the Engineer, tested.

The Environmental Management Plan (EMP) (Also refer part 18, of Volume 2, section 7) shall identify the potential environmental impacts from the various construction and operations and maintenance activities to be undertaken in the Contract and set out in detail the approach he will adopt in mitigating these environmental impacts to ensure that the residual impacts are minor and confined to a short period.

The EMP shall consider, but not be limited to, the following:

- The methods of materials delivery, storage, usage, and disposal; equipment usage; and site activities to ensure they have minimal impact on the environment.
- Only environmentally safe products and practices shall be adopted in performing his works and
- The Contractor shall comply with all applicable statutes regarding environmental effects.

The EMP shall provide separate descriptions of its proposals for minimizing any adverse environmental impacts/effects during the construction phase and the subsequent operations and maintenance phase.

The EMP shall be provided in draft form within 28 days from the Notice to Commence, and shall be updated from time to time by the Contractor as agreed or required by the Engineer to ensure the objectives of environmental protection are fully met.

3.26 Safety

The Contractor shall prepare a Safety Plan and submit it to the Engineer for approval within 28 days of receiving the Notice to Proceed.

The Safety Plan shall be followed at all times by the Contractor and shall contain adequate control measures, with the following the relevant protection of property and local laws and regulations as well as internationally accepted good practice, for the prevention of accidents, fires, and public nuisance.

The Safety Plan shall be implemented properly and diligently throughout the execution of the Works and during the operations and maintenance period.

The Contractor's Safety Plan shall make safety provisions for, among other things:

(a) Deep excavations and collapsing sides in trench excavations.
(b) Scaffolds and overhead working.
(c) Working in confined spaces.
(d) Working in water.
(e) Contractor's equipment, especially cranes, heavy vehicles, etc.
(f) Hand-held power tools.
(g) Electrical equipment, power connection.
(h) Hazardous chemicals, gases, and fuels.
(i) The use of protective clothing and
(j) The provision of first aid facilities.

On-Site Patrol

- The Safety Manager patrols every day (preparation of report & announcement in morning meeting)
- Surprise inspection by the Engineer
- Regular safety exercise
- Morning meeting every day

The Contractor shall at all times in the conduct of his work and that of his Subcontractors adhere to the established rules and regulations concerning all safety matters at Site such as the recommendations contained in the "Manual of Accident Prevention in Construction", published by the Associated General Contractors of America, Inc., or other Internationally recognized recommendations to the extent that such provisions do not conflict with the applicable laws. This is especially important wherever it is necessary to enable the free passage of the public through the Site.

The Safety Plan shall be developed to ensure zero fatal accidents and zero hazardous incidents or occurrences in all construction work. The Safety Plan shall include descriptions of the company's standard policies and procedures regarding its site organization and procedures, methods and frequency

of conducting safety audits at the Site(s), record keeping and reporting, providing safety training for its personnel (including subcontractors), issue and mandatory use of safety equipment, and details of the qualifications and experience of the Bidder's proposed safety officers to be deployed at the Site(s). The Contractor shall provide separate descriptions in its Safety Plan covering the construction phase and the subsequent operations and maintenance phase.

- The Contractor shall appoint a full-time Expert/ Health and Safety Engineer/Manager (Accident Prevention Officer) having the required qualifications and experience in this field, who shall be responsible for implementing the Safety Plan. He should have the authority to issue instructions to the Contractor's personnel regarding protection measures to prevent accidents.
- The Contractor shall provide the public with adequate information on all risks associated with the construction works. If the general public sustains any bodily injury or death, the Contractor shall be responsible for providing all necessary medical care and compensation.

The Contractor shall ensure that his staff, labour, and Subcontractors are all fully trained in and aware of good and safe working practices.

The Contractor shall ensure that all precautions are taken to safeguard the general public and construction/operating staff from any danger.

- During construction, the Contractor shall erect, maintain, and subsequently remove sufficient barricades, guards, lighting, sheeting, shoring, temporary sidewalks and bridges, danger signals, as well as temporary covering of potential accident areas, as approved by the Employer. All temporary and partially completed works shall be protected by way of barriers, lights, notices and the like. All excavations and the like are to be protected by barriers at all times and adequately illuminated at night. An adequate number of Life buoys are to be provided near water retaining structures with a depth of more than 1.2m during the construction and Operation & Maintenance stages.

- All open excavations along pipeline shall be protected sufficiently to keep out livestock, ensure the safety of workmen and members of the public, and be in accordance with the directives of the police and other local regulations.
- The Contractor shall be responsible for ensuring that all persons working in the vicinity of power lines are aware of the relatively large distance that high-voltage electricity can "short" to earth when cranes or other large masses of steel are present in the vicinity of power lines.
- Where work is to be carried out in the proximity of buildings, bridges, tanks or other structures, the Contractor shall take all necessary precautions, including shoring and strutting, where necessary, to ensure the safety of the structures that are at risk.
- The Contractor shall be responsible for all damages or injury which may be caused on any property by trespass by the Contractor's or his Subcontractor's employees in the course of their employment, whether the said trespass was committed with or without the consent or knowledge of the Contractor.

Warning and diversion signs concerning roadwork shall be suitably placed to give motorists ample warning. During the movement of heavy vehicles across roads or onto roads, men, bearing red flags, shall be in attendance to warn other road users and to generally control traffic in a safe manner.

The Safety Plan shall also consider requirements for warning and protection for other risks including overhead and underground cables, pipes or obstructions, or voids, openings, pits and trenches. The Contractor shall ensure that all appropriate measures are implemented.

1. Suitable scaffolds should be provided for workmen for all works that cannot safely be done from the ground, or from solid construction, except such short-period work as can be done safely from ladders. When a ladder is used, an extra mazdoor shall be engaged for holding the ladder. If the ladder is used for carrying materials as well, suitable footholds and hand-holds shall be provided on the ladder, and the ladder shall be given an inclination not steeper than ¼ to 1 (¼ horizontal and 1 vertical).

2. Scaffolding of staging more than 3.6 m above the ground or floor, swung or suspended from an overhead support or erected with stationary support shall have a guard rail properly attached or bolted, braced and otherwise secured at least 90 cm. high above the floor, or platform of such scaffolding or staging and extending along the entire length of the outside and ends thereof with only such opening as may be necessary for the delivery of materials. Such scaffolding or staging shall be so fastened as to prevent it from swaying from the building or structure.

3. Working platforms, gangways and stairways should be so constructed that they should not sag unduly or unequally, and if the height of the platform or the gangway or the stairway is more than 3.6 m above ground level or floor level, they should be closely boarded; should have adequate width and should be suitably fastened as described in (2) above.

4. Every opening in the floor of a building or in a working platform shall be provided with suitable means to prevent the fall of a person or materials by providing suitable fencing or railing whose minimum height shall be 90 cm.

5. Safe means of access shall be provided to all working platforms and other working places. Every ladder shall be securely fixed. No portable single ladder shall be over 9 m. in length, while the width between side rails in a rung ladder shall in no case be less than 29 cm for a ladder up to and including 3 m. in length. For longer ladders, this width should be increased by at least 6 mm for each additional 30 cm of length. Uniform step spacing of not more than 30 cm shall be kept. Adequate precautions shall be taken to prevent danger from electrical equipment. No materials on any of the sites or work shall be so stacked or placed as to cause danger or inconvenience to any person or the public. The contractor shall provide all necessary fencing and lights to protect the public from accidents. The Contractor shall be bound to bear the expenses of defense of every suit, action or other proceedings at law that may be brought by any person for injury sustained owing to neglect of the above precautions and to pay any damages and cost which may be awarded in any such suit, action or proceedings to any such person.

6. Excavation and Trenching - All trenches 1.2 m. or more in depth shall at all times be supplied with at least one ladder for each 30 m. in length or fraction thereof. The ladder shall extend from the bottom of the trench to at least 90 cm above the surface of the ground. The sides of the trenches, which are 1.5 m. or more in depth, shall be stepped back to give a suitable slope or securely held by timber bracing, so as to avoid the danger of sides collapsing. The excavated materials shall not be placed within 1.5 m of the edges of the trench or half of the depth of the trench, whichever is greater. Cutting shall be done from top to bottom. Under no circumstances shall undermining or undercutting be done.

7. Demolition - Before any demolition work is commenced, and also during the progress of the Work,

i) All roads and open areas adjacent to the work site shall either be closed or suitably protected.

ii) No electric cable or apparatus which is liable to be a source of danger or cable or apparatus used by the operator shall remain electrically charged.

iii) All practical steps shall be taken to prevent danger to persons employed from risk of fire or explosion or flooding. No floor, roof or other part of the building shall be so overloaded with debris or materials as to render it unsafe.

8. All necessary personal safety equipment deemed adequate by the Employer should be kept available for use by the person employed on the site and maintained in a condition suitable for immediate use. The contractor should take adequate steps to ensure the proper use of equipment by those concerned.

The following safety equipment shall invariably be provided.

i) Workers employed on mixing asphalt materials, cement, and lime mortars shall be provided with protective footwear and protective goggles.

ii) Those engaged in whitewashing and mixing or stacking of cement bags or any material that is injurious to the eyes shall be provided with protective goggles and nose masks.

iii) Those engaged in welding works shall be-provided with welder's protective eye Shields, nose mask & gloves.

iv) The stone breaker shall be provided with protective goggles and clothing and seated at sufficiently safe intervals.

v) When workers are employed in sewers and manholes, which are in active use, the contractors shall ensure that the manhole covers are opened and ventilated at least for an hour before the workers are allowed to get into the manholes, and the manholes so opened shall be cordoned off with suitable railing and provided with warning signals or boards to prevent accident to the public, in addition, the contractor shall ensure that the following safety measures are adhered to:

a) Entry for workers into the line shall not be allowed except under the supervision of the Engineer.

b) At least 5 to 6 manholes upstream and downstream should be kept open for at least 2 to 3 hours before any man is allowed to enter the manhole for working inside.

c) Before entry presence of Toxic gases should be tested by inserting wet lead acetate paper which changes colour in the presence of such gases and gives indication of their presence.

d) Presence of Oxygen should be verified by lowering a detector lamp into the manhole. In case, no Oxygen is found inside the sewer line, workers should be sent only with Oxygen kit and self-contained breathing apparatus (SCBA).

e) Double lanyard safety harness with shock absorber and rope should be provided to the workers. While working inside the manholes such rope should be handled by two men standing outside with pulley system to enable him to be pulled out during emergency conditions.

f) The area should be barricaded or cordoned off by suitable means to avoid mishaps of any kind. Proper warning signs should be displayed for the safety of the public whenever cleaning works are undertaken during night or day.

g) No smoking or open flames shall be allowed near the blocked manhole being cleaned.

h) The malba (solid waste) obtained on account of cleaning of blocked manholes and sewer lines should be immediately removed to avoid accidents on account of slippery nature of the malba.

i) Workers should not be allowed to work inside the manhole continuously. He should be given rest intermittently. The Engineer may decide the time up to which a worker may be allowed to work continuously inside the manhole.

j) Self-contained breathing apparatus (SCBA) and first aid should always be present at site for use in any emergency.

k) Air-blowers should be used for flow of fresh air through the manholes. Whenever called for portable air blowers are recommended for ventilating the manholes. The Motors for these shall be vapour proof and of totally enclosed type. Non sparking gas engines also could be used but they should be placed at least 2 meters away from the opening and on the leeward side protected from wind so that they will not be a source of friction on any inflammable gas that might be present.

l) The workers engaged for cleaning the manholes/sewers should be properly trained in "Confined Space" before allowing working in the manhole.

m) The workers shall be provided with Gumboots or non-sparking shoes bump helmets and gloves non sparking tools safety lights and gas masks and portable air blowers (when necessary). They must be supplied with barrier cream for anointing the limbs before working inside the sewer lines.

n) Workmen descending a manhole shall try each ladder stop or rung careful before putting his full weight on it to guard against insecure fastening due to corrosion of the rung fixed to manhole well.

o) If a man has received a physical injury, he should be brought out of the sewer immediately and adequate medical aid should be provided to him.

p) The extent to which these precautions are to be taken depend on individual situation but the decision of the Engineer regarding the steps to be taken in this regard in an individual case will be final.

vi) Contractor shall be fully responsible in the event of death of employee/workmen during the execution of the work and liable to pay adequate compensation to the dependants of employee/workmen as per law. On his/their failure, if the Board is made to pay compensation the same shall be recovered by the Board from the contractor out of the amount due to the contractor or by appropriate legal action. If death of any employee occurs during execution of work due to negligence of contractor, the contract may be liable for termination. The Board will be entitled to claim exemplary damages from the contractor in case of death of any workman/employees of the contractor in any of the BWSSB works as it damage the reputation of the Board.

vii) The Contractor shall not employ men and women below the age of 18 years on the work of painting with products containing lead in any form. Wherever men above the

age of 18 are employed on the work of lead painting, the following precaution should be taken:-

a) No paint containing lead or lead products shall be used except in the form of paste or readymade paint.

b) Suitable face masks should be supplied for use by the workers when paint is applied in the form of spray or a surface having lead paint is dry rubbed and scraped.

c) Overalls shall be supplied by the contractors to the workmen and adequate facilities shall be provided to enable the working painters to wash during and on the cessation of work

d) White lead, sulphate of lead or product containing these pigments, shall not be used in painting operation except in the form of pastes or paint ready for use.

i) Measures shall be taken, wherever required in order to prevent danger arising from the application of paint in the form of spray.

ii) Measures shall be taken, wherever practicable, to prevent danger arising out of from dust caused by dry rubbing down and scraping.

iii) Adequate facilities shall be provided to enable working painters to wash during and on cessation of work.

iv) Overalls shall be worn by working painters throughout the entire working period.

v) Suitable arrangement shall be made to prevent clothing put off during working hours from being spoiled by painting materials.

vi) Cases of lead poisoning and suspected lead poisoning shall be notified and shall be subsequently verified by doctor's appointed by the competent authority of BWSSB.

vii) BWSSB may require, when necessary, medical examination of workers, including measuring blood lead levels.

viii) Instructions regarding special hygienic precautions to be taken during painting.

9. When the work is done near any place where there is a risk of drowning, all necessary equipment should be provided and kept ready for use. All necessary steps should be taken for the prompt rescue of any person in danger, and adequate provision should be made for prompt first aid treatment of all injuries likely to be obtained during the work.

10. Use of hoisting machines and tackle, including their attachments, anchorage, and supports, shall conform to the following standards or conditions:

i. i. These shall be of good mechanical construction, sound materials, and adequate strength and free from patent defects and shall be kept repaired and in good working order.

ii. Every rope used in hoisting or lowering materials or as a means of suspension shall be of durable quality and adequate strength, and free from patent defects.

iii. Every crane driver or hoisting appliance operator shall be properly qualified, and no person under the age of 21 years should be in charge of any hoisting machine, including any scaffolding winch, or give signals to the operator.

iv. In case of every hoisting machine and of every chain ring hook, shackle swivel and pulley block used in hoisting or as means of suspension, the safe working load shall be ascertained by adequate means. Every hoisting machine referred to above shall be plainly marked with the safe working load. In case of a hoisting machine having a variable safe working load each safe working load and the condition under which it is applicable shall be clearly indicated. No part of any machine or load. Gear referred to in this paragraph shall be loaded beyond its safe working load, except for testing.

v. The Contractors shall notify the safe working load of the machine to the Employer-in-charge whenever they bring any machinery to the site of work and get it verified by the Electrical Employer concerned.

11. Motors, gearing, transmission, electric wiring, and other hazardous parts of hoisting appliances should be equipped with effective safeguards. Hoisting appliances should be provided with such means as will reduce to the minimum the risk of accidental descent of the load. Adequate precautions should be taken to minimize the risk of any part of a suspended load becoming accidentally displaced. When workers are employed on electrical installations that are already energized, they should use insulating mats and wear appropriate protective clothing. Gloves, sleeves, and boots, as necessary, should be provided. The worker should not wear any rings, watches, or carry keys or other materials, which are good conductors of electricity.

    All scaffolds, ladders, and other safety devices mentioned or described herein shall be maintained in a safe condition, and no scaffold, ladder, or equipment shall be altered or removed while it is in use. Adequate washing facilities should be provided at or near the workplace.

12. These safety provisions should be brought to the notice of all concerned by display on a notice board at a prominent place at the workplace. The person responsible for compliance of the safety code shall be named therein by the contractor.

13. To ensure effective enforcement of the rules and regulations relating to safety precautions, the arrangements made by the contractor shall be open to inspection by the Labour Officer or Employer-in-Charge of the department or their representatives.

14. Notwithstanding the above Clauses from (1) to (13) there is nothing in these to exempt the contractor from the operations of any other Act or Rule in force In the Republic of India.

3.26.1 Additional Safety Guidelines

Following guidelines/instructions should be adhered to in the true spirit:-

1. The door may be fixed at the entry of the staircase and the open portion of the staircase of the sump well should be protected by a grill up to a height of 7 feet, and the compartments of the sump well should be covered with jalis/grating or should be barricaded properly. Sewage pumping station should be secured by providing and fixing barbed wire fencing over the boundary wall.

2. An inspection register should be placed at the sewage pump house, where all inspecting officers can record their observations. No unauthorized entry should be allowed.

3. A caution board showing the restricted entry area and the names of components and the moving mechanical parts should be displayed.

4. The entry to all BWSSB infrastructures should be restricted to the person /persons authorized by BWSSB or having I.D cards issued by the chief security officer.

5. Just after entering the premises do's and don'ts should be displayed at prominent places in all three languages.

6. Even authorized visitors should be provided with proper uniform /visitor badges, helmets, and relevant safety gear and given instructions before showing such infrastructure.

No person below 18 years age should be allowed on the premises where chances of emission of toxic gases are extensive.

3.26.2 National Human Rights Commission (NHRC) Guidelines

NHRC issued guidelines on the safety code for the operation/maintenance of the sewerage system, which have to be strictly followed during the execution of work. Directions given by the Hon'ble Supreme Court in the matter of the National Campaign for Dignity and the Rights of Sewerage and Allied Workers.

1. The medical examination and medical treatment will be given free of charge to sewer workers, and the treatment will continue for all such workers found to be suffering from an occupational disease, ailment, or accident until the workman is cured or until death.
2. The services of the sewer workers are not to be terminated, either by the respondents or the contractors engaged by them, during the period of illness, and they shall be treated as if on duty and will be paid their wages.
3. The respondents shall pay on the death of any worker, including any contract worker, an immediate ex-gratia solatium of one lakh with liberty to recover the same from contractors, if permissible in law.
4. The respondents shall pay/ensure payment of all statutory dues such as Provident Fund, Gratuity, and Bonus to all the sewer workers, including contract workers, as applicable in law.
5. The respondents shall provide, as soon as possible, modern protective equipment to all the sewer workers in consultation with the petitioner organization.
6. The respondents shall provide soap and oil to all the workmen according to the present quota, but on a monthly basis and not at the end of the year.
7. The respondents shall provide all workmen including contract workmen with an accident-card-cum-wage-slip.

3.26.3 Protection of Overhead and Underground Services

- The Contractor will be held responsible for any damage to known services (i.e., overhead services that are visible within the Site and underground services shown on the drawings) and shall take all necessary measures to protect them. All work or protective measures shall be subject to the approval of the Employer. In the event of a service being damaged, he shall inform the Employer and the authority concerned. The Contractor shall not repair any such service unless instructed to do so.

- Contractor will map the underground utilities. Where no underground services are shown on the drawings or scheduled but the possibility of their presence can reasonably be inferred, the Contractor shall, in collaboration with the Employer, ascertain whether any such services exist within the relevant section of the Site. The Contractor shall conduct such an investigation well in advance of the commencement of construction work in the said section and submit a report in a timely manner to enable the Employer to take necessary actions.

- In main roads and junctions, irrespective of utility services indicated in the drawing, the Contractor needs to take proper care prior to commencement of Construction activities so as to ensure minimum disruption to the services. This may require even

making a cross-sectional trial pit to determine the exact alignments of different utilities.

- Taking care of other utility services infrastructure during the execution of the works is the responsibility of the Contractor. Nothing in the Contract should relieve the Contractor from their responsibility towards the safety of other utility services infrastructure during project execution. The Contractor's Construction program should include such activities, and no extra claim towards time of completion, and for consideration, no extra claim regarding time of completion or cost in this regard shall be entertained.
- As soon as any underground service not shown on the drawings is discovered, it shall be deemed to be a known service and the Contractor will be held responsible for any subsequent damage to it.
- Where the authority concerned elects to carry out on its own account any alterations or protective measures, the Contractor shall co-operate with and allow such authority reasonable access and sufficient space and time to carry out the required work.

The Safety Plan shall include a policy statement signed by the CEO or equivalent authority of the Organization declaring that safety and loss prevention shall be given the highest practicable priority in all aspects of the Contract. The Safety Plan shall be updated as necessary to cover the activities to be undertaken for operations and maintenance.

End of Part 3

PART 4

GENERAL WORKMANSHIP, MATERIAL AND DESIGN REQUIREMENTS FOR PLANT

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PART 4

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PART 4

GENERAL WORKMANSHIP, MATERIAL AND DESIGN REQUIREMENTS FOR PLANT

4.1 Introduction

This part of the Employer's Requirements outlines the standards for materials, workmanship, and design that the Contractor must use for the Plant. Reference to any specific material or equipment does not necessarily imply that such material or equipment is to be included in the Works.

All plants used for the works shall, unless otherwise specified, comply with the provisions of this part.

The names of the manufacturers of materials and equipment proposed for incorporation in the Works together with performance, capacities, certified test reports and other significant information pertaining to the same, shall be furnished when requested for consideration by the Engineer, who shall have power to reject any parts which in his opinion are unsatisfactory or not in compliance with the specifications and such parts shall be replaced by the Contractor at no extra cost to the Employer.

4.2 Compliance with Standards

The British Standard specifications shall refer to the latest issue or revision of those standards as issued by the British Standards Institution of 2 Park Street, London W1, and the Indian Standard Specifications as issued by the Bureau of Indian Standards. Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110 001 and ASTM standards as issued by the American Society for Testing and Materials, 1916, Race Street, Philadelphia, PA, 19103, U.S.A and ANSI standards as issued by the American National Institute, 1430, Broadway, New York, NY 10018, U.S.A. Equipment conforming to other national or international standards shall be at least equivalent to those specified and shall be subject to approval by the Engineer. The Contractor shall provide full details of the difference.

Where the design or choice of materials of plants is affected by the Factory Acts, then the materials and plant supplied shall comply with all relevant sections of those Acts even though no particular reference may be made in this specification.

The Contractor shall obtain at least one copy of each IS, BS, ANSI, ASTM, or other approved standard or reference material referred to in the Specification, as well as a copy of all other standards applicable to the materials being supplied to, or workmanship executed on, the works. These standards and reference material shall be supplied to the Employer's Representative within 45 days of the commencement date and will be available to the Contractor at all reasonable times.

4.3 Materials General

All materials incorporated into the Works shall be the most suitable for the duty concerned and shall be new, of first-class commercial quality, free from imperfections, and selected for long life and minimal maintenance.

All submerged moving parts of the plant, including the pins and spindles, as well as the faces in contact with them (such as water, sludge, or sewage), shall be made of corrosion-resistant metals. All parts in direct contact with various chemicals shall be completely resistant to corrosion or abrasion by these chemicals and shall also maintain their properties without aging due to the passage of time,

exposure to light, or any other cause. Where mild steel is specified for submerged parts, the metal shall be protected by polyurethane coating.

Where “stainless steel" is specified or used, it shall have resistance to atmospheric corrosion not less than that provided by Stainless Steel ASTM A 276 Gr. 410 for forgings and BS EN 10293:2015, Grade 410-C-21 for castings. Particular attention shall be given to the prevention of seizure by fretting when two corrosion-resistant metals are in contact, by selecting materials with suitable relative hardness and surface finish, and by applying lubricants. Where bronze is specified or used, it shall be zinc-free, to BS EN 1982:2017.

Particular attention shall be paid to the prevention of corrosion due to the close proximity of dissimilar metals. Where it is necessary to use dissimilar metals in contact, these shall be selected so that the bimetallic corrosion is as low as possible. The publication by H.M. Stationery Office (in the U.K.), entitled “Corrosion and Its Prevention at Bimetallic Contacts," shall be used as a guide.

4.4 Workmanship General

Workmanship and general finish shall be of first-class commercial quality and in accordance with best workshop practice and shall provide what is generally recognised as waterworks finish as defined elsewhere.

All similar items of plant and their component parts shall be completely interchangeable. Spare parts shall be manufactured from the same materials as the originals and shall fit all similar items of plant. Machining fits on renewable parts shall be accurate and to specified tolerances so that replacements made to the manufacturer's drawings may be readily installed.

All equipment shall operate without excessive vibration and with the minimum of noise. All revolving parts shall be dynamically balanced so that, when running at all operating speeds and any load up to the maximum, there is no vibration due to imbalance.

All parts that can be worn or damaged by dust shall be totally enclosed in dust-proof housings.

Dynamic balancing of rotary components shall be to the relevant standards. All bearings shall have an L-10 rating life of a minimum of 16,000 hours.

All instruments used for the works, whether for permanent installation or checks/inspections at the Manufacturer's works or checks/inspections at the site, shall be calibrated using standard reference instruments from institutions recognized by the Government, such as the Institute for Design of Electrical Measuring Instruments (IDEMI), Mumbai.

All outdoor instruments shall be provided with locked, galvanised metallic enclosures of 2 mm thickness, suitably painted.

4.5 Design Life

All materials and equipment shall be designed for long life and shall be suitable for continuous 24-hour per day operation for prolonged periods with a minimum of maintenance, and the Contractor may be called upon to demonstrate this for any component either by the service record of similar equipment elsewhere or by records of extensive type tests.

Routine maintenance and repair shall as far as possible, not require the services of highly skilled personnel.

Except for consumable items such as rubber bushings, gland packings, carbon brushes, etc., which generally require replacement more frequently, no part subject to wear shall have a life from new to replacement or repair of less than three years of continuous normal operation. Where significant dismantling is required to replace a part, such life shall be not less than fifteen years.

4.6 Welding

In all cases where welds are likely to be highly stressed, the Contractor shall supply the Engineer with detailed drawings of all welds and weld preparations proposed before fabrication commences. No welding shall be carried out before the Engineer has signified his approval of the proposed details. No alteration shall be made to any previously approved detail of weld preparation without prior approval of the Engineer.

Welding shall comply with BS EN 1011.

Approval of welding procedures shall be as per BS EN ISO 15614. Welders shall be qualified per BS EN 287-1:2004. All aspects of fabrication and examination procedures, including pre/post-heating treatment, electrodes, and Non-Destructive Tests (NDT), shall be subject to approval of the Engineer.

Contractor shall refer the relevant international codes for the NDTs.

4.7 Castings

All cast iron shall be of standard grey, close-grained quality, as per BS EN 1561/IS 210 Gr 220 Grade or better. The structure of the castings shall be homogeneous and free from non-metallic inclusions and other injurious defects. All surfaces of castings that are not machined shall be smooth and carefully fettled to remove all foundry irregularities.

Minor defects not exceeding 12.5 percent of the total metal thickness and that will not ultimately affect the strength and serviceability of the casting may be repaired by approved welding techniques. The Engineer shall be notified of larger defects, and no repair welding of such defects shall be carried out without prior approval.

If the removal of metal for repair reduces the stress-resisting cross-section of the casting by 25 percent, or to such an extent that the computed stress in the remaining metal exceeds the allowable stress by more than 25 percent, then that casting may be rejected.

Castings repaired by welding for major defects shall be stress relieved after such welding.

Non-destructive tests will be required for any casting containing defects whose extent cannot be otherwise determined, or to verify that repair welds have been properly made.

4.8 Instrument Components

Iron and steel parts shall, in general, be painted or galvanised as appropriate in accordance with the Specification. Indoor parts may alternatively have chromium or copper-nickel plating or other approved protective finish.

Small iron and steel parts (other than stainless steel) of all instruments and electrical equipment, the poles of electro-magnets and the metal parts of relays and mechanisms shall be chromium or copper-nickel plated or have some other approved finish to prevent rust Cores, etc., which are built up of laminations or cannot for any other reason be antirust treated, shall have all exposed parts thoroughly cleaned and heavily enamelled, lacquered or compounded.

4.9 Safeguarding of Machinery

The Contractor shall ensure that all designs and equipment for which he is responsible are safe. Nothing in this Requirement shall relieve the Contractor of their obligation to bring to the Engineer's attention any feature of the Works that is not consistent with safety, or to prevent them from making proposals for incorporating equipment or designs that would enhance the safety of the Plant.

The installation layout and plant design shall not allow any item of plant to be positioned in a manner that could pose a danger to operating personnel during normal operation and maintenance. Particular attention shall be paid to the position of hot pipes, air vents, and rotating machinery.

All rotating shafts, couplings, gears, flywheels, belt drives, or other moving parts shall be fully guarded. Guards shall be designed to provide ready access to bearings, grease points, thermometer sockets, and other check points and to allow safe routine observation and servicing to be executed without the need to dismantle any part of their structure.

4.10 Rating Plates, Nameplates and Labels

All equipment, apparatus, and plant shall be clearly labelled or fitted with nameplates and rating plates generally as follows:

4.10.1 Indoor Type Labels

Labels for the outside of equipment shall be of a rigid type, laminated and engraved plastic material, with black block capitals on a white background. Non-rusting screws, or similar approved shall fix the labels. Labelling inside equipment shall be as above, except that a flexible, self-adhesive type of labelling may be used if suitable for the ambient temperatures and if it is not less than 12 mm in width.

4.10.2 Weatherproof Labels

These labels may be vitreous enamelled or brass. Plastic labels will not be accepted unless proof can be provided that they can withstand the environmental conditions at the site.

Vitreous enamelled labels shall be secured by brass or non-rusting roundhead screws, with brass and fibre washers in contact with the enamel front and back to prevent damage.

4.10.3 Name and Rating Plates

Each main and auxiliary item of plant shall have permanently attached to it in a conspicuous position a nameplate and a rating plate. Upon these shall be engraved the manufacturer's name, type, and serial number of Plant, details of the loading and duty at which the item of Plant has been designed to operate, and such diagrams as may be required by the Engineer. All indicating and operating devices shall have a designation securely attached to or marked upon them indicating their function and the proper manner of use. Provision shall be made to incorporate descriptive numbering codes as indicated on the Record

Drawings. Details of proposed plates, labels, and inscriptions must be submitted to the Engineer for approval prior to manufacture.

4.11 Lubrication

The contractor shall furnish a complete schedule of recommended oils and other lubricants. The number of different types of lubricants shall be kept to a minimum. The schedule and the name of the lubricant supplier shall be submitted to the Engineer for approval before being incorporated into the instruction manuals. In the case of grease-lubricated roller-type bearings for electric motors, lithium-based grease is preferred.

Where lubrication is effected by means of grease, preference shall be given to a pressure system which does not require frequent adjustment or recharging. Frequent, for this purpose, means more than once a week, and grease systems having shorter periods between greasing should be avoided. Where necessary for accessibility, grease nipples shall be placed at the end of the extension piping, and, when a number of such points can be grouped conveniently, the nipples shall be brought together and mounted in a convenient position. Button head type nipples shall be used for normal grease, and all grease nipples shall be of the same size and type for every part of the Plant. Arrangements shall be provided to prevent bearings from being overfilled with either grease or oil.

Where more than one special grease is required a grease gun for each special type shall be supplied and permanently labelled.

Oil lubricated bearings shall be provided with an oil reservoir capable of automatically maintaining the correct oil level within the bearings. It is not necessary to shut down the pump to check the oil level or add oil to the bearings.

Oil sumps shall be fitted with oil level indicators of the sight glass type, or where this is not practicable, with dipsticks. The indicators shall show the level at all temperatures likely to be experienced in service. The normal, maximum, and minimum levels at 20°C shall be clearly visible in the sight glass type from the normal access floor to the particular item of plant, and they shall be easily dismantled for cleaning.

All sight glasses shall be firmly held and enclosed in metal protection in a manner that prevents them from being accidentally dislodged.

All lubrication systems shall be designed to prevent a fire hazard, and particular care shall be taken to prevent the leakage of lubricants and to avoid lubricant leaks coming into contact with any electrical equipment, heated surfaces, or other potential sources of fire.

The Contractor shall supply flushing oil for each lubrication system when an item of plant is ready for preliminary running, and a sufficient quantity of the approved lubricants for setting to work and for the commercial operation of the plant for a period of two years after the taking over certificate has been issued.

4.12 Initial Charges of Oil and Grease, etc.

The initial charges of oil, grease, electrolyte, and similar materials necessary for the correct setting to work and operation of the Plant shall be included in the appropriate Plant item.

4.13 Non-metallic Materials

Fabrics, cork, paper, and similar materials that are not subsequently to be protected by impregnation shall be treated with an approved fungicide. Sleeving and fabrics treated with linseed oil varnish will not be permitted.

The use of organic materials shall be avoided as far as possible; however, where they are unavoidable, they shall be treated to make them fire-resistant and non-flame-propagating.

The use of wood should be avoided whenever possible. If used, woodwork shall be thoroughly seasoned teak or other approved hardwood that is resistant to fungal decay and other blemishes. All woodwork shall be treated to protect it against damage by fire, moisture, fungus, vermin, insects, bacteria, or chemical attack, unless it is naturally resistant to all these. All joints in woodwork shall be dovetailed or tongued and pinned. Metal fittings on wood shall be of non-ferrous material. Adhesives shall be specially selected to ensure the use of types that are impervious to moisture and fungus growth. Synthetic resin cement shall be used for joining wood.

4.14 Engineering Hardware

Nuts, bolts, studs, and washers for incorporation in the Works shall conform to the requirements of the appropriate British or other approved standard. Nuts and bolts for pressure fittings shall be made of the best quality steel, with the shank and under the head and nut being machined.

Bolts shall be of such a length that one thread shall show through the nut when in the fully tightened condition.

Fitted bolts shall be a light driving fit in the reamed holes they occupy, shall have the screwed portion of such a diameter that it will not be damaged in driving and shall be marked in a conspicuous position to ensure correct assembly at site.

Washers, locking devices, and anti-vibration fittings shall be provided as necessary to ensure that no bending stress is applied to the bolt.

Where there is a risk of corrosion, bolts and studs shall be designed so that the maximum stress in the bolt does not exceed half the yield stress of the material under all conditions.

All submerged hardware, including nuts, bolts, studs, washers, and fasteners, shall be made of SS316 material.

All bolts, nuts and screws which are subject to frequent adjustment or removal in the course of maintenance and repair shall be made of nickel-bearing stainless steel.

The Contractor shall supply all holding-down, alignment, and levelling bolts, complete with anchorages, nuts, washers, and packings, required to attach the plant to its foundation. Additionally, the Contractor shall supply all bedplates, frames, and other structural parts necessary to spread the loads transmitted by the Plant to the concrete foundations without exceeding the design stresses.

Unless otherwise necessary to meet special requirements, all threads shall be of preferred metric sizes with standard coarse threads.

ISO metric black hexagon bolts, nuts and screws shall comply with SII 0589-81, or ISO 885:2000, ISO 888:2018, ISO 898-1 and -2: 2013.

ISO metric precision hexagon bolts, nuts and screws shall comply with ISO 272:1982, ISO 4759-1:2000, ISO 885:2000, ISO 888:2018, ISO 898-1 and -2:2018 or ASTM F-593, ASTM F-468 M, strength grade 8.8.

The dimensions of ISO metric countersunk head bolts screws, and hexagon nuts shall comply with ISO 225:2010, or ISO 888:2018, ISO 898-I.

Plain steel washers for use with ISO metric bolts shall comply with ISO 887:2006 or ASTM F-844.

Taper steel washers shall comply with ASTM F-844 and ASTM F-436.

4.15 Instruments

Unless otherwise specified, any indicating and recording instruments supplied under the Contract shall be approved by the Engineer. They shall be flush-mounted, with dust- and moisture-proof covers, and shall be suitable for the environment in which they are installed. Where hinged covers are necessary, they shall be provided with locks.

Indicating instruments shall be of the dial type and shall be provided with a readily accessible zero adjustment.

Dials in general shall be white with black markings and not subject to fading. Scales shall be made of such material that no peeling or discoloration will occur with age under humid conditions.
Motor ammeters shall be capable of withstanding the starting current and shall have a compressed overload scale.

Steel screws, when used, shall be zinc, cadmium or chromium-plated, or where plating is not possible due to tolerance limitations, shall be of stainless steel. Instrument screws (except those forming part of a magnetic circuit) shall be of brass or bronze. Springs shall be non-rusting materials, eg, phosphor-bronze or nickel-silver, as far as possible. Pivots and other components for which non-ferrous materials are unsuitable shall be made of stainless steel.

Pressure gauges shall be at least 150 mm in diameter, unless otherwise approved. The internal components shall be made of stainless steel, bronze, or another corrosion-resistant material, excluding aluminium. The gauges may be mounted directly on the pipework or side by side on a board or panel. Each pressure gauge shall be fitted with a stop cock immediately adjacent to the gauge, and all pressure gauge piping shall be fitted with an isolating valve at each point of connection to the main system and drain valve for draining purpose. Where pressure gauges are mounted on panels, the isolating valve shall be suitable for the connection of a test gauge. Stop cocks of gauges shall be clearly identified by means of separate labels of approved type and lettering.

All fixed pipes with a nominal bore below 25 mm shall be compression jointed with heavy-gauge copper, where this material is suitable. In other cases, pipe materials are to be approved by the Engineer. All pressure gauges shall be fitted with an air release cock and hydraulic pressure snubbers to protect them against shock pressures.

4.16 Piping and Equipment Layout

In general, all pipes and fittings shall be steel or ductile iron with flanges to BS EN 1092-1 & 2.

Where steel and cast flanges are mated together, the steel flange shall be machined over its full face, after welding to its respective pipe is completed.

Flexible joints shall be provided to facilitate the installation, removal, and/or differential movement of the plant. Where required, flexible joints shall be provided with tie bolts or other means to transfer longitudinal thrust along the entire length of the pipework.

The pipework shall be laid out and designed to facilitate its erection, in situ painting, dismantling of any section for maintenance, and to ensure a constant and uniform flow of working fluid with a minimum loss in head. When steel pipework is used, the number of flanges should be kept to a minimum, with the size of each unit of pipework determined by the ease of handling, installation, and the overall appearance of the completed pipe system. Positions of flanges shall take into account any necessary concrete pipe supports or thrust blocks.

Facilities shall be provided for draining the pipe system. Where a pipe passes through a wall, retaining wall, or is subject to thrust, it shall incorporate a puddle flange that conforms to the dimensions stated in BS EN 1092-1 but remains undrilled.

Unless otherwise specified, nuts, bolts, and washers for pipework shall conform to the requirements of BS EN 1092-1.

Bolts shall be of sufficient length that one thread shall show through the nut when in the fully tightened condition.

4.17 Gaskets and Joint Rings

Joint rings shall be manufactured to conform to BS 7874, BS EN 681-1, BS EN 681-2, and BS EN 682, and shall be made of chloroprene rubber or other approved synthetic materials suitable for temperatures up to 80 °C.

Joints shall be made in accordance with the manufacturer's instructions or as specified herein.

Until immediately required for incorporation in a joint, each rubber ring or gasket shall be stored in the dark, free from the deleterious effects of heat or cold, and kept flat to prevent any part of the rubber from being under tension.

Only lubricants recommended by the manufacturer shall be used in connection with rubber rings, and these lubricants shall not contain any constituent soluble in water of the quality stated in the Requirements, shall be suitable for the climatic conditions at the site, and shall contain an approved bactericide.

After cleaning the flanges, the gaskets shall be fitted smoothly to the flange and the joint made by tightening the nuts to finger pressure first. Thereafter the final tightening of the nuts shall be made by gradually and evenly tightening bolts in diametrically opposite positions using standard spanners.

Graphite grease shall be applied to the threads of bolts before joints are made.

4.18 Steelwork

Any small areas of chequer plating or similar covering that are necessary to cover gaps between items of Plant and the surrounding structure, and any access ladders, platforms, and handrails that must be attached to items of Plant to facilitate operation, inspection, or maintenance, shall be supplied, and erected by the Contractor.

The Contractor shall include in their contract provisions for providing adequate means of access to all hand wheels, sight glasses, gauges, lubrication points, and any other items to which access is necessary for routine maintenance.

All chequered plates shall be of Durbar or other non-slip patterns, not less than 6.0 mm thick (exclusive of pattern), with Aluminium Material of Construction (MOC).

4.19 Spare parts

The Contractor shall also supply the details of recommended spare parts and the quantity required for the continuous operation of the Works for a minimum period of ten (10) years, as detailed in the Price Schedule. The cost of spare parts shall not be taken into consideration. It shall not be binding on the Employer to purchase any or part of the spare parts recommended by the contractor. The spare parts required shall be decided prior to the award of the contract or during the execution of the contract, which shall be binding on the contractor.

All spare parts shall be new, unused, and strictly interchangeable with the parts for which they are intended as replacements. They shall be treated and packed for long-term storage under the prevailing climatic conditions at the site. Each spare part shall be clearly marked or labelled on the outside of its packing with its description and purpose, and when more than one spare is packed in a single case or other container, a general description of its contents shall be shown on the outside of such case or container and a detailed list enclosed. All cases, containers, and other packages must be marked and numbered in an approved manner for identification purposes.

All cases, containers, or other packages are liable to be opened for such examination as the Engineer may require, and packings shall be designed to facilitate opening and thereafter repacking.

"Spares, accompanied by technical details/leaflets etc., shall be delivered to the site before the start of commissioning tests. Spare parts shall be indicated in the assembly drawings of respective plant items with clear details of part numbers. Contractor shall also furnish the manufacturer's recommendations on spares for respective plant items."

All spare requirements specified shall be instantaneous. (i.e., an equal amount of used spare shall be replaced with new spares to maintain the minimum spare quantity specified in the bidding document) throughout the O&M period.

4.20 Tools and test Equipments

The contractor shall supply the details of recommended special tools and test equipment required to enable any erection, dismantling, or testing to be carried out on any part of the Plant, whether of an electrical, mechanical, or any other nature, during the life of the Plant, and shall be listed in the Price Schedule. The cost of Tools and Test equipment shall not be taken into evaluation. It shall not be binding on the Employer to purchase any or all of the tools and test equipment recommended by the

contractor. The tools and testing equipment required shall be specified prior to the award of the contract or during its execution and shall be binding on the contractor.

The tools and test equipment shall not be used for the erection of the Plant. Except as the Engineer may require the Contractor to demonstrate their use or effectiveness, they must be handed over to the Employer in a completely new and unused condition. Should the Contractor require any such tools and test equipment at the site during erection, he shall provide his own.

The tools for each type of equipment shall be contained in a suitable box, clearly marked, or labeled with its description. Each tool shall be identified, and a list of tools shall be affixed to the inside of the box lid. Each set of tools shall be supplied with the equipment with which it is associated.

The test equipment shall include only special-purpose items essential to the testing or recalibration of related plant items.

The tools provided shall include clamps, wrenches, lifting lugs, grease guns, gauges, test rigs, jigs, or extractors which may be required for the life of the plant. All tools and test equipment shall be clearly detailed, including size, capacity, etc.

4.21 Protection and Packaging for Transportation

Before any Plant is dispatched from a manufacturer's works, it shall be properly prepared and packed.

Prior to despatch, all Plant shall be adequately protected by painting or by other approved means for the whole period of transit, storage, and erection, against corrosion and incidental damage, including the effects of vermin, sunlight, rain, high temperatures, and humid atmospheres. The Contractor shall be held responsible for ensuring that the Plant is packed and/or protected to reach the site intact and undamaged. The Plant shall be packed to withstand rough handling in transit, and all packages shall be suitable for storage, including possible delays in transit.

The Contractor shall be deemed to have included in the Schedule of Prices for all materials and packing cases necessary for the safe packaging, conveyance, and delivery of the Plant.

The flanges of pipes, valves, and fittings shall be protected by wooden discs attached by means of service bolts (which shall not be used on-site) or by other approved means. The sleeves and flanges of flexible couplings shall be bundled by wire. Cases containing rubber rings, bolts, and other small items shall not normally weigh more than 500 kg gross.

No one package or bundle shall contain items of the plant intended for incorporation in more than one section of the works.

All items of Plant shall be clearly marked for identification against the packing list.

Every crate or package shall contain a packing list in a waterproof envelope. A duplicate copy of the packing list shall be sent by post to the Engineer at the site.

All crates, packages, and other items shall be clearly marked with a waterproof material to indicate the weight and the location where the slings should be attached. They shall also have an indelible identification mark relating them to the packing lists.

End of Part-4

PART 5

PROCESS REQUIREMENT

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PART 5

PROCESS REQUIREMENT

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PART 5

PROCESS REQUIREMENT

5.0 PROCESS REQUIREMENT

Process, hydraulic and other plant design requirements for the TSPSs, WwTPs and LPSs of this Contract are described herein Part 5 – "Process Requirement".

5.1 Wastewater Treatment Plants with Terminal Sewage Pumping Stations

Design requirements for the following Wastewater Treatment Plants (WwTPs) with Terminal Sewage Pumping Stations (TSPSs) that are included in this Contract are part of "Works – A" and are to be provided as follows.

S.No.	Zone	WwTP Location	Average Flows (MLD)
1	Mahadevapura	Channasandra	20 MLD

All the WwTPs including its TSPS shall be designed and constructed for the given flows and pollution loads with treatment process as defined in Paragraph 5.20

5.2 Lift Pumping Stations (LPSs) and Associated Pumping Mains

Design requirements for the following Lift Pumping Stations (LPSs) that are included in this Contract are part of Works – B and are to be provided as follows.

S.No.	Zone	LPS Name	Average Flows (MLD)
1	Mahadevapura	Halasahalli	0.9 MLD

Design requirements for the following Lift Pumping Mains are included in this Contract and are described as follows. Lift Pumping mains are part of Works – B and are to be provided as follows.

S.No	Pumping Main		Diameter (mm)	Length (m)
	From	To		
1	Halasahalli	To Ridge Machine hole	150	1000

Notes:

1. *Length may be subject to adjustment during Contract based on topographic survey and other factors.*

5.3 Influent Wastewater Characteristics

The influent wastewater characteristics to be used as the basis of design are listed in Paragraph 5.20 – "TSPS & WwTPs Design/Sizing Criteria and Other Requirements".

5.4 Effluent Quality Requirements

The treated effluent quality requirements to be met are listed in Paragraph 5.20 –"TSPS & WwTPs Design/Sizing Criteria and Other Requirements".

5.5 Effluent Quality Requirements for Reuse

The treated effluent quality requirements for reuse to be met are listed in Paragraph 5.20 –"TSPS & WwTPs Design/Sizing Criteria and Other Requirements".

5.6 Dewatered Sludge Quality Requirements

The dewatered sludge quality requirements to be met are listed in Paragraph 5.20 – "TSPS & WwTPs Design/Sizing Criteria and Other Requirements".

5.7 Noise Levels Requirements

The requirements of noise levels to be met are listed Paragraph 5.20 – "TSPS & WwTPs Design/Sizing Criteria and Other Requirements".

5.8 Treatment Process

The main treatment process train for each TSPS and WwTP shall consist of the major unit processes and components listed in Paragraph 5.20. This list shall not be considered as a comprehensive description. The Contractor shall provide a complete, fully functional facility designed for proper, easy operation and to meet the stated performance requirements. This shall include any and all additional, ancillary, supporting, or other processes, components, equipment, or other items necessary to achieve these objectives, regardless of whether such items are explicitly listed in this Bidding Document or not.

The design/sizing criteria, minimum number of units, and other requirements for the various unit processes and components are listed in Paragraph 5.20.

5.9 Demolition or Interfaces and Tie-Ins with Existing Facilities

All existing facilities that are to be demolished shall be properly decommissioned, removed, and appropriately disposed-off by the Contractor in accordance with all applicable laws, regulations, and standards. Items, components, or materials, whether buried, exposed, submerged, or otherwise, shall not be abandoned or left on site unless explicitly indicated in the Bidding Document. For facilities that are to be eventually demolished but must remain in service until alternate or replacement facilities are constructed and commissioned, whether under this Contract or a different Contract, the Contractor shall ensure that the facilities are protected and remain functional until such time as the alternate or replacement facilities are constructed, tested, commissioned, and accepted by Employer.

All existing facilities that must remain in service permanently shall be protected by the Contractor such that they remain fully functional, operable, and serviceable throughout construction, testing, and commissioning of the new facilities. The Contractor shall be fully responsible for installation and, if necessary, ultimate removal of any temporary facilities or connections (piping, utilities, power, controls, etc.) that may be necessary to maintain existing facilities fully operational throughout construction and commissioning. Temporary or permanent interfaces between existing and new facilities may involve making connections or "tie-ins" to existing live structures, piping, wiring, cabling, equipment or other components. The Contractor shall be fully responsible for detailed design, planning, and implementation of such interfaces in a safe and secure manner.

5.10 Modular Design, Construction, and Operation for Reliability, Redundancy, Turndown, and Easy Future Expansion

This paragraph shall be read in conjunction with other relevant paragraphs and parts of the bidding documents. The design and construction of the proposed works under this contract shall be executed such that future expansion to the build out capacity can be accomplished easily and in a modular manner while maintaining the proposed capacity fully operational at all times. The Contractor's submittals and drawings shall clearly show and describe the expansion and how the works can be accommodated within the constructed facilities of Site.

For all components under this Contract, the capacity to be provided shall be designed and constructed using multiple, suitably sized unit process modules to ensure reliability, redundancy, and appropriate turndown for optimum capacity utilization and process efficiency. The minimum number of working and standby modules or units required for each component shall be provided by the contractor as listed in Paragraph 5.20.

5.11 Design of Plant Layout

The TSPS and WwTP components shall be laid out and fully contained within the respective designated site boundaries so as to logically interface with the sewers and/or pumping mains that are to be connected to the TSPS/WwTP to be constructed under this Contract and all existing infrastructure that may be present at the sites and that must remain in service, if and as appropriate.

The layouts shall be planned and designed, such as to optimize the connections between the (i) the inlet(s) to the LPS and the sewers which are to be constructed under this Contract, but under different Conditions of Contract and (ii) inlet(s) to the TSPS and the pumping mains/sewers and the sewers which are to be constructed under this Contract, But under different Conditions of Contract, as mentioned above. In doing so the Contractor shall take full account of the design responsibilities under Works – A and Works – B and take full responsibility for designing, planning and programming the Works within individual sites, this is essential for the interfaces between Works – A and Works – B of this contract.

The Contractor's proposed site layout for TSPS and WwTP shall clearly show the space allocated for all plant components, including those components and/or unit processes that are designated for future construction or installation. Setbacks and clearances from the site boundary shall be provided as appropriate and as required by law. (e.g., KSPCB).

All existing utilities (including water, sewer, power, or others, whether overhead or underground and whether physically located on the site or not) requiring to be relocated to accommodate the Contractor's proposed and approved site layout shall be relocated by the Contractor at no additional cost and without interrupting provision of such utility services to users and customers. Such relocations shall be fully coordinated with the Employer.

The plant layout shall adhere to the following minimum requirements, regardless of whether or not such requirements or any related components are shown in any drawings or specifically listed or described in any part of the document included in the Contract Document.

- Prior to finalizing the plant layout for approval, the contractor is required to present a comprehensive 3D model walkthrough video showcasing the entire plant layout and its facilities to the Engineer.

- Minimum clear distance provided to permit safe and convenient access for operation and maintenance shall be 3m between adjacent treatment units or fixed structures and 1.2m between pieces of equipment.
- Minimum clear distance of 1.2m shall be provided between two adjacent screen channels to permit safe and convenient access for operation and maintenance.
- Access and maintenance lay down area shall be provided adjacent to all mechanical equipment.
- All electrical equipment (except for motors) shall be located above the high flood level elevation for the site or for the effluent receiving water body, whichever is higher.
- All process units / storage tanks shall be labeled with name, sizes and volume. Letters shall be of a size suitable for the application but shall not be less than 100mm high. Labels shall be located at 90-degree intervals at a suitable elevation.
- All plant items for mechanical, electrical and instrumentation shall be fitted with a unique name plate bearing the individual plant reference name for the plant item.
- Contractor shall generate master asset database of each plant (TSPS and WwTPs) under this contract and should update same during O&M period. Further, all assets shall be labeled with unique asset number with QR code which shall be linked to master asset database of plant and shall provide all details of asset when scan the QR code.
- Access facilities shall be provided for People with Disabilities; at minimum for all the locations at Finished Ground Level and Finished Floor Level.
- Admin building shall be provided with three side glass capsule Elevator having capacity to carry minimum Eight (8) People at a time.
- Contractor shall provide bird eye view of entire plant by constructing viewing area above admin building. Further, contractor shall ensure that elevator of admin building shall terminate at bird eye view area.
- Minimum 1500mm wide continuous walkway shall be provided for walkthrough of liquid stream process units which shall start at Inlet Chamber of TSPS/WwTP and end at Chlorine contact tank outlet channel and there after sludge stream units terminating at PLC/SCADA room. Crossing of this walkway with plant internal road shall be painted as “WALKWAY”.
- Minimum 1200mm clear width of platform shall be provided to all process units like TSPS, Inlet works, aeration works, clarifiers, Disc filters, CCT, thickeners, sludge sumps and any other location as required to meet the access requirement as specified in tender.
- Vehicular access shall be provided for all plant structures and buildings. A pedestrian access door shall be provided adjacent to each vehicle access door in a building. Vehicular routes within buildings shall be clearly marked and process equipment, pipes, cables etc. shall not be located within one (1) meter of a marked vehicular route; appropriate physical protection shall be provided for equipment, pipes, cables etc. located close to a vehicle access route to minimize the risk of damage.
- All plant internal roads and plant approach road shall be of asphalt macadam and minimum width shall be as specified in tender document.
- All the roads shall be provided with minimum Curb radius of 3.5m unless specified otherwise.
- All roads shall be provided with storm drain on either side of road or single side based on drainage flow pattern and shall be constructed to prevent standing water.

- All the roads shall be provided with painted concrete curb stone on both side of road with minimum concrete curb stone height as 300mm.
- Minimum 750mm of paved walkway shall be provided on either side of road which shall be 300mm above the road surface. Contractor shall propose storm drain below this walkway.
- Contractor shall ensure that all plant internal roads shall be provided with 100mm edge line marking, this shall be marked at 300mm away from curb stone on both sides of road with industrial grade paint.
- Proper drainage of the area around all the buildings shall be provided to avoid stagnation of rain water to prevent malarial conditions.
- Contractor shall appoint dedicated Architectural Engineer for developing Architectural view of complete plant, further contractor shall ensure that architectural view of all process and non-process building shall reflect the current era architecture as approved by Engineer.
- Contractor shall appoint dedicated Landscaping Engineer for developing Landscape layout of complete plant, further contractor shall ensue that landscaping view of complete plant should be pleasant and shall reflect modern landscaping practice of current era.
- Plantation & horticultural activities of landscaped area shall be properly maintained to give pleasant environment of build out campus throughout the O&M period.
- The speed limit for all vehicles within plant boundary shall be not more than 15kmph and same shall be displayed at suitable locations within plant road, at least at road intersection. Further, all the road intersection within plant shall be provided with direction boards at suitable elevation as directed by Engineer.
- Display hoarding for safety signs at suitable elevation shall be provided both indoors and outdoors. These safety signs shall cover mandatory, prohibition, warning, emergency, fire-fighting and general notices as directed by Engineer.
- Display hoarding of painted plant layout shall be placed outside the admin building at suitable elevation as directed by Engineer.
- A Scale model of all the facilities within the plant boundary shall be displayed inside the Admin building with brief description of each unit process. Model shall be kept inside the glass box having dimensions 2.4m Length x 1.8m Width x 0.45m Height. The Model shall be placed at suitable height above the Finished Floor Level as directed by Engineer.
- All process and non-process buildings including pumping stations shall be provided with wall mounted digital display touch screen of size 15 inches to digitally display real time temperature and noise level of the respective buildings, and same shall be connected through plant PLC based SCADA for remote monitoring/display.
- While preparing the layout, The contractor is required to establish a robust safety framework, incorporating comprehensive operator training, detailed operation and maintenance manuals, automated alarming systems to facilitate prompt responses to abnormal conditions, installation of CCTV cameras in the plant for round the clock monitoring and implementation of emergency evacuation systems, and the deployment of protocols for directing personnel away from occupied areas in case of emergencies. Furthermore, the layout design should involve zoning for different activities to mitigate overpressure risks in designated areas of the plant.

5.12 Design Requirements

The following design requirements shall be meant for all TSPSs, WwTPs and Pumping Mains. These requirements shall be fully met regardless of whether or not such requirements or any related components are shown in any drawings and other documents included in the Contract Document.

- All designs for Civil, Mechanical, Electrical, and ICA (Instrumentation, Control, and Automation) works by the contractor shall adhere to the latest revisions of the relevant BIS (Bureau of Indian Standards) specifications, Codes of Practice, or applicable international standards as per the tender requirements. All these standards shall reflect the most recent revisions, including revisions that occurred during the design and approval stage of the contract.
- The Contractor shall perform a complete Hazardous Area Classification analysis as per IS 5572 for all TSPSs, and WwTPs in this contract and shall submit a complete report of such analysis as well as Hazardous Area Classification Drawings that delineate boundaries of all classified areas and indicate the classification of each area. All electrical or other powered equipment, instrumentation, or components shall fully comply with all requirements of IS 5571.
- Receiving chamber, trash & coarse screen channels including its associated gates and screening mechanism of TSPS, shall be placed outside the wet well. Placement of all these components inside the wet well is not allowed.
- All components (including but not limited to equipment such as pumps, blowers, screens, diffusers, inline devices; instruments such as flow meters; and distribution and collection channels or pipes) shall be provided with appropriate isolation devices such as valves, gates, or other devices in order to allow isolation, drainage, cleaning, calibration, servicing, and maintenance of such components.
- To ensure operational stability and continuous flow to the plant, all magnetic flow meters shall be equipped with a bypass arrangement that includes isolation gates and drain valves. Isolation gates shall be installed both upstream and downstream of the flow meter and on the bypass pipeline (Total 3 Nos), to enable isolation of the flow meter from the main flow without disrupting the plant's operation. Additionally, drain valves of minimum diameter 100 mm shall facilitate the safe draining of fluid from the pipe prior to the removal or maintenance of the flow meter.
- All electromagnetic flow meters shall be installed with a minimum straight length of five times the pipe diameter from upstream flange side and two times the pipe diameter from downstream flange side of the flow meter. These straight pipe lengths shall exclude any valves and fittings on both the upstream and downstream flange sides of the flow meter.
- All flow meters including its isolation, bypass and drain valves shall be placed in valve chamber with proper access and drain arrangement. No flow meter shall be allowed to install vertical in direction. Also, valves shall have extended spindle and chamber shall be covered with Aluminium chequered plate. Height of the flow meter chamber shall be minimum 500mm above the FGL and floor level of chamber shall be minimum 300mm from bottom of pipe flange.
- All equipment, where necessary and particularly blowers, shall be provided with acoustic, sound-dampening enclosures to limit ambient noise during normal operation to the limits as detailed in Part 14.

- Suction air filters provided for process air blower shall capable of supply the process air that should not contain more than 0.02 mg of dust per m^3 of process air.
- Cooling arrangement shall be provided to ensure process air temperature of less than 60°C at outlet of each air blower discharge.
- Contractor shall provide back flow prevention mechanism / check valve inside each diffuser to prevent intrusion of liquid and/or solids into the diffuser and air piping under normal operating conditions of aeration system.
- All equipment shall be arranged, and buildings and structures designed to permit safe and easy access to and removal of all equipment.
- Fixed runways, lifting eyes, cranes, hoists, or other appropriate devices and means shall be provided to permit safe and easy removal of all equipment for maintenance or any other purpose.
- Minimum 1.5 factor of safety shall be incorporated over maximum weight to lift while selecting the capacity of any type of lifting device.
- All structures, whether liquid-holding or not, shall be designed such that they can be fully and completely drained and will not float or move when empty, because of groundwater buoyancy or any other reason. The structures shall be designed to counteract any possible floatation without the use of any type of groundwater pressure relief valves, including during construction.
- The floors of all liquid-holding structures shall be appropriately sloped and trenches and drain sumps shall be provided at the bottoms of such slopes to facilitate complete drainage of liquid. Appropriate drain pipes and valves connected to the drain sump(s) shall be provided for all structures. Where the drain pipe connects to the structure, the top-of-pipe elevation shall be at least 150 mm lower than the lowest floor elevation for the structure. The drain piping shall be routed from the structure being drained to the Plant Drain Pump Station. For liquid-holding structures, the drain piping and fittings shall be sized such that the entire structure can be drained by gravity in no more than eight (8) hours. The Plant Drain Pumping Station, Plant Drain Pumps, and other related equipment and controls shall be designed and sized to allow draining of the structure with the largest volume from full to empty within eight (8) hours. The highest design water level (High-High Alarm) in the Plant Drain Pumping Station wet well shall be at least 300 mm lower than the lowest pipe invert elevation amongst all drain pipes connecting to the wet well.
- Non-liquid-holding areas, structures, or buildings where leakage or other wet activities can occur, whether in normal use or during maintenance, shall be provided with covered drainage channels which shall direct the spillage either to a suitable gravity drain or to a sump equipped with standard dual submersible sump pumps discharging to the Plant Drain Pump Station.
- Interceptor and containment bunds shall be provided for containment of all chemicals, fuel and wash water as a resultant from spillages and overflows. The Contractor shall take due regard to the potential of hazardous mixing of chemicals, particularly as a result of leaks and spillages, and their drainage and containment.
- All concrete structures in contact with sewage and/or sludge shall be provided with full interior corrosion protection linings and/or coatings; this shall applies to all concrete structures in contact with any type of sewage and/or sludge anywhere in the plant including but not limited to complete works of TSPS, Inlet works, Anaerobic zone, Anoxic zone, Aerobic zone, Clarifiers, Sludge storage tanks, Channels etc.,

- Complete chlorine contact tank including its free board and its inlet & outlet channel shall be provided with White/Sky Blue porcelain - like finish free from any pits or recesses to avoid accumulation of bacteria and dirt, else which might hinder to achieve desired outlet fecal coli-form.
- Complete disc filtration tank including its free board and its inlet & outlet channel shall be provided with White/Sky Blue porcelain - like finish free from any pits or recesses to avoid accumulation of bacteria and dirt, else which might hinder to achieve desired outlet fecal coli-form.
- All channels carrying process liquid shall be fully covered with solid non-skid GRP cover plates (not grating) designed for human traffic live loads at a minimum and heavy vehicle live load wherever the channel crosses traffic paths.
- Inlets into tanks, reactors, or other structures via pipes, channels, valves, or gates shall be designed such that the incoming flow does not cause any damage or excessive wear whatsoever to the structure (including corrosion protection linings and/or coatings) or any equipment in the vicinity under any hydraulic condition, including but not limited to the condition when the structure is empty.
- Walkways, flooring, hand railing, Plant, etc. shall be designed to take account of the prevailing conditions and be of corrosion-resistant materials. The Contractor's attention is drawn in particular to areas including, but not limited to TSPS, and Inlet Works.
- All walkways and staircase shall be provided with non-skid floor tiles of industrial grade designed for human traffic live loads and equipment load that carried on walkway. Whereas all the admin building requirements including staircase, flooring etc., shall be as specified elsewhere in this Bidding Document.
- Dedicated working area shall be provided on aeration tank for proper access, lifting and maintenance of installed mixers, valves, flow meters and pumps.
- Apart from dedicated lay-down area for diffusers which shall be provided near the aeration tanks, contractor shall also provide dedicated working area on aeration tank for proper lifting, maintenance and reinstallation of retrievable diffusers. For this, contractor shall provide minimum 2400mm clear width of operating platform for aeration tanks with retrievable diffusers arrangement.
- flooring of blower room and all type of pump house buildings shall be non-skid in nature and shall be designed to allow for Plant to be removed and stored on the flooring where required for maintenance, in accordance with the Tender requirements and as per good engineering practice.
- Platforms, handrails/guardrails, ladders, stairs and safety chains shall be provided for proper, safe, and easy access to and/or operation of valves, gates, instruments, control panels, and other devices, equipment, or structures, as well as removal of the above items. All platforms and handrails shall be provided with toe guards of minimum 100mm width.
- RCC staircases shall be provided to all treatment plant units, flow dividing chambers and other structures to connect to the elevated RCC walkway platforms for which the height of the floor above finished ground level exceeds that in the prevailing standard.
- All piping shall be of corrosion–resistant material appropriate for the service and shall be provided with interior lining, exterior coating, and other corrosion protection as appropriate and necessary to meet the requirements for design life. All piping shall be fully and adequately

supported and braced to comply with all applicable codes and standards. All supporting hardware shall also be of corrosion-resistant material. The design of pipe supports, and anchors shall fully account for static and dynamic vertical, lateral, longitudinal, and seismic loads, fluid flow, and thermal expansion. Seismic bracing thrust restraints and/or thrust blocks, and appropriate expansion joints or loops shall be provided as needed. Pipe lengths and joints shall be assembled and arranged for ease of removal in such a way that individual runs can be changed without dismantling adjacent pipes, by providing dismantling joints at regular intervals.

- All mixed liquor and sludge lines shall be provided with appropriate cleanouts and flushing arrangements for safe and easy flushing using high-pressure water of minimum 3.5kg/cm^2.
- All liquid service pipes shall be provided with appropriate means for safe and easy drainage of the pipes when not in service.
- All pipelines shall be color banded and suitably labeled with the stream designation and direction of flow to enable individual lines to be identified throughout their run. Particular attention shall be paid to the painting of each chemical line, which shall be based on type of chemical flowing in pipe.
- Particular attention shall be paid to the layout of the chemical piping, ensuring that it is arranged in a clutter-free manner while being functional and neat in appearance. All chemical piping system shall be designed and installed with clear identification and ease of access for maintenance. Where piping is installed in ducts, it shall be supported at a minimum clearance of 300 mm from the floor.
- To enhance the efficiency and to reduce the on-site installation time for the chemical dosing system, contractors are advised to consider a pre-fabricated, fully integrated, skid-mounted chemical dosing systems. These systems shall be designed for easy installation, minimizing the need for additional on-site adjustments. These systems shall be tested off-site (Factory) before delivery, ensure that all components, including pumps, valves, flow meters, and control systems, are arranged to optimize space, functionality and in full compliance with overall plant design requirements as specified in tender document.
- All piping routed under any type of structure or equipment shall be fully and completely encased in reinforced cement concrete, with the encasement thickness beyond the outer diameter of the pipe being at least 200 mm on all sides. The encasement shall extend along the pipe length for a minimum horizontal distance of 1500 mm in each direction beyond the footprint of the overlying structure or equipment.
- All piping connecting to, entering, or exiting any and all structures shall be provided with appropriate restrained flexible connections and/or joints at all such interfaces with structures to allow for differential movement between pipe and structure in all directions without stressing or breaking the pipes.
- Appropriate restrained flexible connections and/or joints shall be provided for all pipes where they connect to any and all of the following:
    - Equipment such as pumps, blowers, or inline devices
    - Valves
    - Wall, floor, or roof penetrations

- Where piping or other materials susceptible to damage from direct sunlight/ultraviolet radiation, they shall be protected from such light/radiation through the use of appropriate additives and/or coatings and shall be physically shielded from direct sunlight/ultraviolet radiation at all times (including prior to and during installation) in their normal service location using enclosures, covers, canopies, roofs, and/or other similar means.
- During cleaning cycle of centrifuge, no spillage or washed flows of centrifuge shall fall on the floor of sludge loading area from sludge hopper; design of centrifuge piping arrangement and sludge hopper shall be done such that all washed flows of centrifuge shall pass through centrate line of centrifuge.
- RCC mezzanine floor shall be provided for sludge screw conveyor area of centrifuge building and shall have staircase access. Further, mezzanine floor shall be provided with proper drainage facilities.
- Sludge loading area of centrifuge buildings where sludge wet activities will occur during normal operation of sludge loading, shall be provided with high pressure water jet spray to clean the accumulated material from the floor to the top perforated drainage channels which shall direct the spillage and cleanout water to the sump equipped with standard dual submersible sump pumps discharging to the main sludge sump.
- High pressure water jet spray shall be provided to clean the accumulated screening material from both mechanical coarse screen and fine screens to ensure smooth operation while resume from standby to working condition and vice versa.
- For secondary clarifiers, the design shall provide for separate and independent measurement and control of the flow rate of sludge withdrawal from each individual clarifier. Such individual control shall be achieved through direct withdrawal of sludge from each unit using one or more dedicated pumps and feedback flow control using separate measurement of flow from each unit. Designs using a common suction header or common wet well shall not be acceptable.
- Appropriate sampling ports and/or sampling valves shall be provided to allow easy, safe sampling of all process streams without spillage or contamination and without the need to interrupt normal operation.
- Foam, scum, fats, oil, grease, or any other floating material removed from any location in the WwTP shall be completely removed from the process flow path and under no circumstances returned / recycled to any location in the plant.
- All spare requirements specified for diffuser membrane, disc filter cloth, mixers and other spare parts of electromechanical equipment's shall be instantaneous. (i.e., equal amount of used spare shall be replaced with new spares to maintain the minimum spare quantity specified in bidding document) throughout the O&M period.
- The placement height of all exhaust fans and lighting fixtures in the specified process and non-process buildings shall be in accordance with relevant industry standards and guidelines. To ensure optimal performance, safety, and ease of maintenance, all these installation shall consider the specific requirements of each building type and the nature of the contaminants or conditions being managed. Additionally, all these components shall allow easy access for maintenance personnel by providing/considering, access platforms, ladders, or other means of safe access within the building for maintenance of all these components.

- Contractor shall ensure that all necessary provisions and features shall be incorporated in all electrical designs and installation to monitor process specific energy consumption. Such energy consumption shall be displayed locally through multi-function energy meter and same shall be connected through plant SCADA for remote monitoring/display. These dedicated facilities shall be provided at minimum of the following locations viz.,
    - TSPS units
    - Preliminary Treatment Units
    - Biological Treatment Units (Including blowers)
    - Reuse Treatment Units
    - Sludge Handling Units
    - Other miscellaneous Units.
- While selecting any type of pump and blower, priority shall be given to higher pump/blower efficiency and lower power consumption and shall ensure that pump/blower can operate at high efficiency throughout its service life. At minimum contractor shall ensure efficiencies of pump/blower as listed below:
    - Minimum efficiency of Submersible Pumps for TSPS shall be 70%
    - Minimum efficiency of Axial Tubular Pump (MLR) shall be 70%
    - Minimum efficiency of RAS Pump (Horizontal/Vertical Non-clog solid handling) shall be 65%.
    - Minimum efficiency of Sludge Pump (Progressive Cavity/Screw pump) shall be 45%.
    - Minimum efficiency of Rotary Tri-Lobe blower shall be 70%
    - Minimum efficiency of Centrifugal Turbo blower shall be 90%
- The Works shall be designed and operated and maintained to minimize odours within, at the boundary of and in the vicinity of the Sites. The layouts of the Works shall take account of the prevailing wind direction and speed at different times of the year. Mature trees shall be provided around the full boundary of all sites, except for at accesses to the sites.
- Following requirements shall be met while preparing the layout and General arrangement drawings of the multi-tier SBR tanks.
    - The contractor shall ensure that there shall be a free air circulation and ventilation available to the lower level SBR tank at all times. This shall be achieved by providing a minimum clearance of 5.0m from the top of the lower level SBR tanks to the bottom of the beams in the upper level SBR tank raft slab, this also ensures a free access to the lower level SBR tank for maintenance.
    - Minimum clear width of 1.5m walkway (Excluding any parapet wall, handrails or columns) shall be provided to both lower and upper level of SBR tanks.
    - Minimum width of the stair case proposed to access the various tiers of the SBR tanks shall be 1500mm with minimum rise of 125mm, tread of 300mm and landing length of 1500mm.
- Following requirements shall be met while preparing the layout and General arrangement drawings of the Chlorination building with a neutralization pit and chlorine scrubbing system, if proposed above the chlorine contact tank.

- The top of the chlorine contact tank shall be equal to "Water Level + Free Board" or "FGL + 500mm", whichever is high, as per plant hydraulics.
- There shall be a free air circulation to the chlorine contact tank water surface at all the times. This shall be achieved by providing a minimum clearance of 900mm from the top of the chlorine contact tank to the bottom of the beams in the chlorination building floor slab.
- To avoid accidental fall, this 900mm clearance shall be covered with corrosion resistant wire fencing with mesh size 40mm and wire diameter 2.5mm
- Corrosion resistant paint shall be provided to the bottom of the chlorination building floor slab, whereas tiling in the chlorine contact shall be as per the requirement specified in tender document.

5.13 Hydraulic Design Requirement

Contractor shall submit self-explanatory hydraulic design calculations in editable MS-Excel format and shall ensure that the plant layouts and hydraulic profiles shall comply with the following specific and all other requirements described in the Bidding Document.

- During the finalization of various levels of all process units as per the hydraulic design, the contractor shall ensure that water levels are rounded to the 0.05m, while the overall liquid depth are rounded to the 0.05m. Whereas individual weir lengths and channel widths are rounded to the 0.1m.
- The contractor shall ensure that Hydraulic Flow Diagram (HFD) of all the proposed works shall truly depict the true flow path of the system. The HFD shall clearly illustrate the sequence and direction of flow through each stage of the treatment process by clearly depicting all the process units and interconnecting hydraulic elements like pipes, chambers, channels etc., from the initial influent entry point to the final effluent discharge, thereafter showing the details for sludge treatment units, individual process and non-process buildings. By providing a precise representation of all the process and non-process works details with all required levels, this drawing along with plant layout shall serve as a valuable master drawings for preparing detailed engineering documents/drawings of the all proposed works.
- While preparing the Hydraulic Flow Diagram (HFD), the contractor shall ensure that the following minimum mandatory annotation shall be indicated at their respective locations in the HFD drawing, namely:
    - Name of the respective process units, non-process units and buildings.
    - Respective water levels for N-1 condition, Peak flow, Average flow and Lean flow level.
    - Raft levels and top of the respective structures.
    - Invert level and top of the respective pipes.
    - Width of the respective channels.
    - Diameter of the respective pipes.
    - Length of the respective weirs.
    - Opening size of the respective gates.
    - Other levels like High Flood Level, Natural Ground Level, Finished Ground Level, Finished Floor Level etc.,

And any other pertinent details and design notes necessary for a comprehensive understanding of the hydraulic system, ensuring completeness and accuracy in the drawing with respect to hydraulic calculations shall be provided in the HFD drawing. Contractor to note that above information shall be represented in the HFD drawing at their respective locations in the form of annotation only.

- The Contractor shall provide at all TSPSs and WwTPs all necessary facilities for manual bypass of the process liquid at various locations in the flow path as indicated below. These facilities are included in this contract and shall be provided regardless of whether or not they are shown in any drawings included in the Bidding/Contract Document. They shall be fully functional in all respects and shall include any and all components necessary to safely and efficiently accomplish the intended bypass. Each bypass facility shall include, but not be limited to: (i) downward opening overflow weir installed in the appropriate channel or structure from which the bypass is to be affected, (ii) an appropriately sized buried (above ground piping shall not be acceptable) pipe to carry the bypass flow from the channel or structure. An appropriately sized flow meter along with all associated components and infrastructure to automatically measure and record details of all bypass events, including but not limited to date, start time, end time, continuous flow rate data for the entire duration of the event, and a totalized volume for the event, shall be provided.
- At minimum, the following locations at the WwTP/TSPS shall be provided with bypass flow arrangement which shall be sized to handle plants peak flows for design as specified in the tender document:
    - At the TSPS Inlet Chamber upstream of the trash screens to the final outfall structure by gravity.
    - At the WwTPs Downstream of the Grit Chambers and upstream of the Parshall Flume to the final outfall structure by gravity.
- Location of outfall structure to discharge treated sewage shall be as directed by Engineer. However, contractor shall ensue that outfall structure shall be located nearest to the receiving water body and flow shall be discharged with cascade effect.
- Topographical survey information, benchmarks, contour maps, and effluent receiving water body high flood level (HFL) elevations for TSPS and WwTP sites are included with these Bidding Documents and/or available from the Employer on request. However, the Employer makes no guarantees or representations whatsoever regarding this information. The Contractor's use of this information shall be at his own risk. The Contractor shall independently obtain any and all site information necessary for proper planning, design, construction and operation and maintenance of all Works/components in the Contract.
- All aspects of the design of the hydraulics shall be based on sound principles and good common engineering practice typical for wastewater treatment works.
- All process units shall be capable of passing the required peak sewage flows, including returned flows as specified.
- All the flows shall be evenly distributed between the numbers of process units in operation for all flow conditions.
- The hydraulic design calculations shall demonstrate the hydraulic functioning of the WwTP if any one of the process units were to be out of service for maintenance.

- Hydraulic calculations shall be based on the Hazen-Williams formulae for pipe and the Manning equation for open channel flow.
- For TSPS and WwTP hydraulics, Hazen-Williams co-efficient of 100 shall be considered for all liquid pipelines for gravity and pumping design.
- For all type of gravity channels, Manning co-efficient of 0.015 shall be considered in design.
- The head loss calculations in all sludge pipe work shall take account of the specific sludge characteristics for different types of sludge including the variations in viscosity arising from changes in the dry solids content and characteristics of the sludge.
- If Contractor's design of sludge line hydraulics is based on Hazen-Williams formula then, Hazen-Williams co-efficient of 50 shall be considered for all sludge piping both for gravity and pumping design.
- The division of flow between the individual treatment units shall be achieved by:
    - Non-submerged (i.e. with a positive free-fall from weir invert to the water surface on the downstream side) overflow weirs followed by isolation gate.
    - Non-submerged downward opening overflow weir gates.
    - All air / sludge flow distribution shall be with automatic feedback flow control using inline flow measurement and modulated flow control valves with actuators and data input and control through PLC/SCADA.
- Sharp crested weirs with free discharge shall be used and shall be designed to include adequate provision for maintaining atmospheric pressures beneath the nappe.
- A positive free-fall of at least 150mm shall be provided to upstream weir crests under peak flow conditions with all streams operational.
- All the flow distribution boxes shall be equipped with adjustable weir plate for equal flow distribution to each side of weir plate. Further, weir followed by isolation gate shall be provided for each weir side of flow distribution box.
- Weir length of flow distribution box shall be designed to give maximum 150mm of head over the weir at peak flow condition.
- SS 316 weir plate with minimum 6mm thick shall be provided on each weir side of flow distribution box and shall be capable to adjust at least 75mm of its height unless specified otherwise.
- All flow distribution boxes shall be of RCC construction inclusive of the weir structure. Proper access shall be provided to facilitate the operation of isolating gates, as well as for checking and adjusting the adjustable weir plate of the flow distribution box. Additionally, provision shall be made for high pressure water jet spray system to effectively disperse any accumulated materials from the water surface of the flow distribution box, whereas any floating material shall be properly removed from the flow distribution box for efficient flow distribution.
- For flow distribution box, at least 1.5m of clear liquid height shall be provided between tip of the weir and invert level of flow distribution box, unless specified otherwise.
- Where flow distribution box receives the flow from channel, the connecting point between incoming channel and flow distribution box shall be provided with minimum 600mm of chamfer followed by under flow baffle wall.

- All pipes and channels shall be provided with proper slope based on calculation. Also, shall ensure that provided slopes shall facilitate draining of pipes and channels when required during maintenance. At minimum following slopes shall be considered in design unless specified otherwise:
    - All pipe lines carrying plant drain and scum shall be provided with minimum 1% of slope.
    - All channels carrying liquid shall be provided with calculated slope or minimum 1% of slope
    - All gravity sludge lines shall be provided with minimum 1.25% of slope
    - All below ground pumped sludge lines shall be provided with minimum 0.4% of slope.
    - Gravity flow either liquid or sludge shall not be permitted to flow against the slope.
- Bed level of all channels shall be provided with slope, Slope shall be provided either by constructing the bed level of channel as per calculated slope or by providing screeding in channel. If channel is provided with screeding to achieve slope, then a minimum 50mm thick screeding shall be considered at lowest discharge point of channel and accordingly calculated slope shall be provided to upstream side of channel. Contractor shall make a note that flat-bed level of channel without slope is not accepted.
- All corners of channel in contact with liquid shall be provided with fillet having minimum radius of 150mm. Further, change in flow path/direction of channel shall be achieved with smooth curve to avoid turbulence in flow.
- All corners of aeration basin in contact with liquid shall be provided with fillet having minimum radius of 450mm.
- All side corners in contact with liquid in chlorine contact tank shall be provided with fillet having minimum radius as specified in paragraph 5.20. Whereas for other corners of chlorine contact tank in contact with liquid shall be provided with fillet having minimum radius of 300mm.
- All corners in contact with liquid in sludge storage tank/sump and any other storage tank/sump shall be provided with fillet having minimum radius of 450mm.
- The termination end of all the baffle walls proposed in aeration tank and CCT shall be provided with semicircular end.
- Special care shall be taken to control turbulence, where Raw Sewage, RAS and MLR flows discharge into aeration tank. Following design feature are illustrated to control the excessive turbulence in both anaerobic zone and anoxic zone and other process unit locations:
    - Construction of the drop chimney/chamber which shall drop the flows to 900mm above bottom of tank. Further plan area of drop chimney/chamber shall be based on velocity criteria which shall be not more than 0.45m/s based on flow to be handled. Alternatively, Construction of the under-flow baffle wall across the flow path which shall terminate 450mm above the bottom of tank with 5minutes retention time based on plant average flow.
- All below water RCC columns proposed in aeration tank or any other process unit shall be circular in shape.
- Minimum number of subzones with physical partition to be provided in each anaerobic and anoxic zone is indicated in paragraph 5.20. However, contractor shall ensure that flow path

through subzones of each anaerobic and anoxic zone shall create the long plug flow condition. Contractor to note that short plug flow design for anaerobic and anoxic zone are not accepted.

- Submersible type mixer shall be installed in each subzones of anaerobic and anoxic zone. Further, mixer shall be in a location where it shall create dispersion to mix and not to settle condition in flow path of each sub-zone.
- For all structures containing water or process liquid, the minimum freeboard (distance by which top of wall / bottom of slab in case of walkway or closed tank is higher than the maximum water surface level at receiving water under one unit out of service condition for all flow condition shall be 0.5m unless specified otherwise.
- All pumps shall have flooded suction and negative suction shall not be allowed in pump selection.
- Maximum pipe flow velocity shall be no more than 1.0 m/s for all gravity flow and pump suction lines unless specified otherwise.
- Maximum pipe flow velocity shall be no more than 1.5 m/s for all pumped discharge lines unless specified otherwise.
- Calculated normal velocity (at 20°C and 1atm) of air piping shall not be more than 16 m/s.
- For channels, the maximum velocity shall be no more than 1.0 m/s.
- For liquids the maximum velocity through gate opening shall be no more than 0.8 m/s unless specified otherwise.
- Maximum velocity through inlet ports of secondary clarifier shall be not more than 200 mm/s.
- The size of magnetic flow meter shall be same as that of pipe diameter unless specified otherwise.
- The minimum elevation difference between (i) High water level and High-High water level (ii) Low water level and Low-Low water level shall be at least 300mm.
- The effective Side Water Depth (SWD) of any wet well / sump for any type of pumping station shall the difference of High Water Level to Low Water Level
- The height of the operating platform for all thimble-mounted gates shall be designed to accommodate the full range of the gate opening. Accordingly, the clear height from the invert level of the thimble-mounted sluice gate to the top of its operating platform shall be at least 2.5 times the full range of the gate opening.

5.14 Inlet Machine-hole to TSPSs

For each TSPS included in this contract that receives raw sewage by gravity directly from one or more BWSSB sewer(s), existing or to be provided under this Contract, Contractor shall be responsible for collecting and conveying the sewage through such sewer(s) to TSPSs inlet machine-hole located within the TSPSs/WwTPs boundary, as specified in this Contract Document. Such sewers shall include those to be provided under this Contract. The limit of Works under Works – A and Works – B are also included in the Contract.

The Contractor for this Contract shall construct the inlet machine-hole for TSPSs under Works A and coordinate the exact location and elevation of such machine-hole with Works B of same contract. Contractor shall be responsible for the incoming pipe(s) to the machine-hole, where there is an existing sewer or a proposed sewer, which directly falls under the responsibility of another organization, for example BDA. However, the Contractor shall be fully responsible for proper coordination to ensure proper alignments and interfaces, and for proper implementation of all connections. If indicated elsewhere in this Bidding Document. However, the Contractor shall be fully

responsible for proper coordination to ensure proper alignments and interfaces, and for proper implementation of all connections.

For each TSPSs included in this Contract that receives sewage from Works B included in this Contract, the Contractor shall be fully responsible for the entire scope of work for the TSPS as specified in this Contract Document, as well as for all connecting piping, including proper alignment, interfacing, and implementation of all pipe connections at both ends.

5.15 Common Facilities

Process and Facilities intended to provide the processes and types of facilities that the Contractor shall be required to design, construct, and operate, and apply to TSPS, and WwTP in this Contract unless specifically indicated otherwise. The Contractor shall use list as indicated in paragraph 5.20 together with other specific information for TSPS and WwTP provided elsewhere in this Bidding Document, all of which are integral to this Process and Facilities and Contractor shall strictly comply with the specified requirement, flow configuration (connectivity between unit processes and facilities), performance requirements (such as quality and equipment efficiencies), and design criteria (such as design operating conditions, various process loading rates and/or detention times, requirements for units out of operation, volumes, and dimensions where specified) such as the requirements specified in the paragraph 5.20.

Apart from major process units and sizes that are covered in the paragraph 5.20 of this tender document, here the description of the common facilities/units/buildings of the WwTP and TSPS.

5.15.1 Admin Building

A fully furnished independent administration building, as specified in the bid document, shall be provided. Strictly, the administration building shall not be attached to any process/non-process building, electrical buildings, or any other process or non-process structure. The administration building shall have a minimum clearance of 3 meters from all four sides and proper ventilation system from each side. Further, admin building shall have two independent RCC staircase access, out of which one functions as common stair case whereas other functions as emergency exit purpose.

- *A Scale model of all the constructed facilities within the plant boundary shall be displayed inside the Admin building with brief description of each process unit. The scale model shall be kept inside the glass box having minimum dimensions of 3.0m Length x 2.4m Width x 0.45m Height. The Model shall be placed at suitable height above the Finished Floor Level as approved and directed by Engineer.*

At minimum, admin building shall include reception, laboratory room, conference hall, engineers rooms (3 No's), pantry, toilet blocks in all floors, master SCADA room and any other facilities that shall be required as per the bid document shall be provided for a fully functional facility of WwTP as described in the Bidding Document.

5.15.2 Security Building

Security building shall be provided as specified in the bid document. At minimum, security building shall have furnished desk with computer and dedicated toilet block and any other minimum facilities that shall be required as per the bid document for the fully functional security system of WwTP as described elsewhere in the Bidding Document.

5.15.3 Plant Drain Sump and Pumping Station

The contractor shall provide a plant drain sump with pumping station as indicated in Paragraph 5.20, to collect drain from various process unit within the WwTP, including but not limited to, flows from solids processing recycles, disc filter backwash and other miscellaneous waste flows such as those from cleaning and wash-down activities (Like sludge loading area of centrifuge) within the plant. The collected flows from plant drain pumping station shall be pumped back to the D/S of the fine screen effluent channels of the WwTP for subsequent treatment within the WwTP.

5.15.4 Scum Pit and Scum Pumping Station

The contractor shall provide a scum pit with a scum pumping station as indicated in Paragraph 5.20. A plant scum pit with a pumping station shall be provided to collect only the filtrate from scum generated from Bioreactor tanks, Secondary Clarifier units of the WwTP. The collected filtrate shall be pumped back to the Centrifuge Feed Sump.

5.15.5 Plant Water System

The entire plant water requirement shall be taken from the treated water storage tank and shall be used for the multiple applications including but not limited to all the chemical solution preparation, motive water system, filter backwash system, general cleaning and flushing needs of the plant.

Additionally, wherever plant water has possibility of direct or indirect human contact (like landscaping) shall meet “Non-Detectable Fecal Coli-form” standards with chlorine free.

A separate overhead tank shall be provided for the plant water system. A pressurized plant water booster system shall be provided, which shall operate based on the pressure set point on the plant water ring main to supply plant water to all of the selected applications through the pressurized plant water ring main. Plant water booster system shall be designed to maintain a minimum pressure of 4.0 bar at the furthest point on the ring main from the booster set under conditions of maximum plant water in use. Pressure gauges, Pressure indicating transmitters etc., complete with the isolation valves shall be provided and fitted to the all delivery lines and booster set pressure vessels of the plant water system.

The plant water ring main shall have hose connection hydrants as required for the cleaning of principal process units and equipment. All potential points of spillage shall be provided with the hose connection hydrants for washing down within buildings and areas where sludge or liquor spillage will occur. All such hydrants shall be specially identified as “Non-Drinking Water”.

5.15.6 Tanker Filling Station

Contractor shall provide the facilities for tanker filling by installing dedicated “treated water transfer pumps” as specified in Paragraph 5.20. For direct filling of these tankers, rising main of the treated water transfer pumps shall be terminated outside the boundary at suitable height and location as directed by Engineer.

Further the WwTP locations (refer Paragraph 5.20.) where the reuse facilities are not specified, then a dedicated ultrafiltration unit with disinfection facilities shall be installed for the tanker filling station of the WwTP (Capacity shall be same as treated water transfer pumps) to ensure the treated water meets all the time stringent re-use standards and non-detectable fecal coliform levels before being loaded into the tankers. For capacity of treated water transfer pumps refer Paragraph 5.20.

5.15.7 Potable Water System

Complete potable water system shall be provided for the use of the safety showers, domestic potable needs and laboratory needs. An underground break tank of minimum capacity 7000 Litres shall be provided to receive the metered potable water to the site for the intended potable use as directed by Engineer.

Further, a skid mounted 500 LPH RO purifier shall be installed near the admin building, which will function to meet the desired portable water standards.

A separate booster set to supply potable water to a potable water ring main/overhead tank shall be provided along with pressurized potable water booster system, which shall be operated based on the pressure set point on the potable water ring main to supply potable water to all of the selected applications / locations as directed by Engineer.

Potable water booster system shall be designed to maintain a minimum pressure of 1.5 bar at the furthest point on the ring main from the booster set under conditions of maximum potable water in use. Pressure gauges, Pressure indicating transmitters etc., complete with the isolation valves shall be provided and fitted to the all delivery lines and booster set pressure vessels of the potable water system.

5.15.8 Compact Pre-Treatment Units

The bidder can propose either a conventional RCC based pre-treatment system comprising RCC channels and chambers installed with screening and grit mechanism as detailed in Paragraph 15.20.1 or a factory-fabricated compact type pre-treatment unit.

In case of compact type pre-treatment system, the bidder shall ensure that the design is suitable for treating high-strength sewage characteristics as detailed in Paragraph 15.20.1

The screening part of the compact type pre-treatment system, shall be capable of handling variable solid loading and shall include an automated fine mechanical screen with an opening size of 4 mm. The screen shall be equipped with compaction and dewatering arrangements and shall effectively remove floating and fibrous matter.

Similarly, the automated grit mechanism shall be proposed in the compact type pre-treatment system, shall be capable of efficiently handling high grit loads, including fine and heavy particles, without affecting downstream processes.

Since compact units are enclosed, the bidder shall propose odour removal system, additionally, the compact type pre-treatment system shall have easy access and maintenance platform of minimum 1.5m, and shall include facilities for inspection, manual cleaning, access to control panels, instruments and emergency interventions as needed and directed by Engineer

The supporting structure for the compact type pre-treatment system shall be robust in design and shall capable to handle static and dynamic load of the units. The elevation of the system shall be suitable to maintain the hydraulic profile as designed, accordingly, the system shall be placed in elevated support structure with proper anchor support to maintain the unit stability.

The proposal of compact type pre-treatment system shall not lead to any additional head loss when compared to conventional RCC systems, and the overall hydraulic profile of the WwTP shall remain unchanged for both proposal.

The contractor's proposal for compact type pre-treatment system shall be supported with:

- Verified performance data demonstrating equivalent or superior performance,
- At least five (5) reference installations treating sewage of similar characteristics and flow capacity, and
- Manufacturer's credentials and experience for the past five (5) years, including documentation of successful implementation and operational history.

Only proposals that are thoroughly substantiated and aligned with process performance expectations shall be considered acceptable for approval.

Description	Details
Type	Factory-fabricated compact type pre-treatment unit
Life Span of the system	All rotating/mechanical parts of the compact unit shall have a minimum service life of 15 years, and all static/non-rotating components shall have service life of minimum 30 years.
Complete MOC of the system	SS 316L
Minimum thickness of static/non-rotating components	8mm
Design flow per unit	Designed for Peak Flows including recycle flows
Number of working and standby screen and grit units	Refer paragraph 15.20.1
Free Board	Refer paragraph 15.20.1
Type of screening system and other screen details	Refer paragraph 15.20.1
Type of Grit mechanism system	Refer Part 8 of Volume 2 Section 7
Other grit mechanism details	Grit generation rate: 0.15 m3/mL Maximum organic content in disposable grit: 3% Minimum grit removal rate: 90% For any other details refer paragraph 15.20.1
Screening and grit collection system	Chute arrangement shall be provided with disposal height up to the collection container at the ground level.
Sampling ports	Suitable sampling ports/point shall be provided to collect the sewage samples from the system

5.16 Alternative Option for Clarifiers

In the base design (Refer Paragraph 5.20) circular clarifier with a center-column supported center drive and center feed arrangement has been recommended for clarifier.

However, the contractor shall have the option to propose a "Rectangular Clarifier" with a chain and flight mechanism, provided the proposed alternative is fully compliant with the design intent and performance requirements.

The rectangular clarifier, if proposed, shall be of the chain and flight type, featuring full-width flights for both sludge and scum collection. The sludge scraper system shall ensure effective transport of

settled solids toward a properly sized sludge hopper. Scum collection shall be facilitated via a continuous surface skimming system with scum baffles and beach-type scum troughs to ensure effective surface scum removal.

The contractor shall guarantee the hydraulic and solids separation performance of the proposed rectangular clarifier system, ensuring it matches or exceeds the performance of the recommended circular clarifier design. All other process design parameters, including Surface Overflow Rate (SOR) and Solids Loading Rate (SLR), shall be as defined for the circular clarifier. Refer Paragraph 5.20.

The contractor's proposal for rectangular clarifier shall be supported with:

- Verified performance data demonstrating equivalent or superior settling efficiency,
- At least five (5) reference installations treating sewage of similar characteristics and flow capacity, and
- Manufacturer's credentials and experience for the past five (5) years, including documentation of successful implementation and operational history.

Only proposals that are thoroughly substantiated and aligned with process performance expectations shall be considered acceptable for approval.

5.17 Flow Measurement

A complete flow measurement facility shall be provided at minimum locations as specified below to measure the flows at minimum 99% accuracy. All equipment and components necessary for a fully functional facility shall be provided for all flow measurement locations regardless of whether or not such items are specifically listed or described in the Bidding Document.

Flow Meter Location	Process
Process locations where electromagnetic type flow meter shall be provided	
Common discharge line from raw sewage pumps	For All Processes
Overflow/bypass line from TSPS to final outfall structure	For All Processes
Bypass line before the Parshall flume to final outfall structure	For All Processes
RAS flow measurement from each secondary clarifier (on Suction Side of RAS pump)	For EA, IFAS, MBBR Process
RAS flow measurement on common discharge line	For EA, IFAS, MBBR Process
RAS flow measurement to each anaerobic zone	For EA, IFAS, MBBR Process
RAS flow measurement to each anoxic zone	For EA, IFAS, MBBR Process
Tapping of WAS flow from common RAS discharge line with its flow measurement	For EA, IFAS, MBBR Process
RAS flow measurement from each SBR tank (If RAS flow considered)	For SBR Process
WAS flow measurement from each SBR tank	For SBR Process
Final effluent flow measurement at outlet of CCT	For All Processes
Common discharge line from Alum dosing pumps	For All Processes
Common discharge line from plant drain pumps	For All Processes

Flow Meter Location	Process
Delivery side of each centrifuge feed pump	For All Processes
Delivery side of each poly dosing pump	For All Processes
Common discharge line from plant water pumps	For All Processes
Common discharge line from Treated water pumps	For All Processes
Common discharge line from Scum Transfer Pumps	For All Processes
Process locations where Parshall flume type flow measurement shall be provided	
Common flow measurement after vortex grit chamber	For All Processes
MLR flow measurement to each anoxic zone	For EA, IFAS, MBBR Process
Common Disc filters bypass flow measurement	For All Processes
Process locations where thermal mass type flow meter shall be provided	
Process air flow measurement to each Aerobic Zone	For All Processes
Locations where electromagnetic type flow meter shall be provided for Reuse System	
Common discharge line from outlet of UF system to inlet of Reuse (GLR)	For Reuse

All the above locations shall be provided with continuous flow measurement. Flow measurement devices shall provide instantaneous and totalized flow records and signals. Flow measurement devices shall be linked to the PLC/SCADA system to allow daily totalized flow and other flow trends to be analyzed, recorded and for control of process as specified in tender document.

5.18 Sampling/Analysis Locations and Frequencies

Sampling and analysis shall be performed to measure the parameters indicated in the table below, at the locations and frequencies indicated in the table. In case of multiple units (such as multiple aeration basins, multiple clarifiers), the indicated sampling and analyses shall be performed for each individual module. Further, Contractor shall ensure that all the historical sampling data and analysis results shall be stored in database as specified in the tender document and made available to Employer till end of contractor's O&M period.

Further, appropriate sampling ports and/or sampling valves shall be provided to allow easy, safe sampling of all process streams without spillage or contamination and without the need to interrupt normal operation shall be provided to meet the specific sampling requirement in each process stream.

Parameter	Frequency	Measurement / Sampling Method	Points / Locations
pH	Continuous	Online	1) Raw Sewage at TSPS 2) Sewage at D/S of Parshall Flume 3) Final Effluent
	Daily	Grab sample	1) Anaerobic Zone 2) Anoxic Zone

Parameter	Frequency	Measurement / Sampling Method	Points / Locations
			3) Aerobic Zone 4) All plant bypass flows 5) Sludge cake
COD	Daily	Flow-weighted 24-hours composite sample	1) Raw Sewage at TSPS 2) Sewage at D/S of Parshall flume 3) Final Effluent
		Grab sample	1) All plant bypass flows
	Continuous	Online	1) Raw Sewage at TSPS 2) Final Effluent
TSS	Daily	Flow-weighted 24-hours composite sample	1) Raw Sewage at TSPS 2) Sewage at D/S of Parshall flume 3) Final Effluent
		Grab sample	1) All plant bypass flows 2) Waste Activated Sludge (WAS) 3) Sludge feed to Centrifuge 4) Sludge cake from centrifuge 5) Plant Drain Flows
	Continuous	Online	1) Raw Sewage at TSPS 2) Final Effluent
VSS	Daily	Flow-weighted 24-hours composite sample	1) Raw Sewage at TSPS 2) Sewage at D/S of Parshall flume 3) Final Effluent
		Grab sample	1) All plant bypass flows 2) Waste Activated Sludge (WAS) 3) Sludge feed to Centrifuge 4) Sludge cake from centrifuge 5) Plant Drain Flows
Chlorine	Daily	Grab sample	1) All plant bypass flows 2) Final Effluent 3) Plant Water
	Continuous	Online	1) CCT Inlet 2) CCT Outlet
Turbidity	Continuous	Online	1) U/S of Disc Filter 2) D/S of Disc Filter
ORP	Continuous	Online	1) Anaerobic Zone 2) Anoxic Zone 3) Chlorine Contact Tank

Parameter	Frequency	Measurement / Sampling Method	Points / Locations
BOD_5 at 20°C	Daily	Flow-weighted 24-hours composite sample	1) Raw Sewage at TSPS 2) Sewage at D/S of Parshall flume 3) Final Effluent
		Grab sample	1) All plant bypass flows 2) Sludge cake from centrifuge 3) Plant Drain Flows
	Continuous	Online	1) Raw Sewage at TSPS 2) Final Effluent
Ammonia-N	Daily	Flow-weighted 24-hours composite sample	1) Raw Sewage at TSPS 2) Sewage at D/S of Parshall flume 3) Final Effluent
		Grab sample	1) All plant bypass flows 2) Anaerobic Zone 3) Anoxic Zone 4) Aerobic Zone
Nitrate-N	Daily	Flow-weighted 24-hours composite sample	1) Sewage at D/S of Parshall flume 2) Final Effluent
		Grab sample	1) All plant bypass flows 2) Anaerobic Zone 3) Anoxic Zone 4) Aerobic Zone
Total Nitrogen	Daily	Flow-weighted 24-hours composite sample	1) Final Effluent
		Grab sample	1) All plant bypass flows 2) Sludge cake from centrifuge
	Continuous	Online	1) Final Effluent
Alkalinity	As needed	Flow-weighted 24-hours composite sample	1) Raw Sewage at TSPS 2) Sewage at D/S of Parshall flume 3) Final Effluent
		Grab sample	1) All plant bypass flows 2) Anaerobic Zone 3) Anoxic Zone 4) Aerobic Zone
Total Phosphorus	Daily	Flow-weighted 24-hours composite sample	1) Raw Sewage at TSPS 2) Sewage at D/S of Parshall flume 3) Final Effluent
		Grab sample	1) All plant bypass flows

Parameter	Frequency	Measurement / Sampling Method	Points / Locations
			2) Anaerobic Zone 3) Aerobic Zone 4) Sludge cake from centrifuge
Fecal Coli-form	Daily	Flow-weighted 24-hours composite sample	1) Raw Sewage 2) Final Effluent
		Grab sample	1) All plant bypass flows 2) Plant Water
Total Coli-form	As needed	Flow-weighted 24-hours composite sample	1) Raw Sewage 2) Final Effluent
		Grab sample	1) All plant bypass flows 2) Plant Water
MLSS	Daily	Grab sample	1) Anaerobic Zone 2) Anoxic Zone 3) Aerobic Zone
MLVSS	Daily	Grab sample	1) Anaerobic Zone 2) Anoxic Zone 3) Aerobic Zone
Temperature	Daily	Online	1) Raw Sewage at TSPS 2) Aerobic Zone 3) Final Effluent
Specific Gravity	As needed	Grab sample	1) Chemicals 2) Sludge
Concentration / Water Content	As needed	Grab sample	1) Chemicals 2) Sludge 3) Grit
Organic Content	Daily	Grab sample	1) Grit
Volume	Daily	Grab sample	1) Chemicals 2) Screenings 3) Grit 4) Dewatered Sludge Cake
Sludge Volume Index	Daily	Grab sample	1) Aeration Basin Effluent Channel
DO	Daily	Grab sample	1) Sewage at D/S of Parshall flume 2) Final Effluent
	Continuous	Online	1) Aerobic Zone
Microscopic Examination	Monthly Once or as needed	Grab sample	1) Raw Sewage at TSPS 2) Anaerobic Zone

Parameter	Frequency	Measurement / Sampling Method	Points / Locations
			3) Anoxic Zone 4) Aerobic Zone 5) Final Effluent
Odour	Weekly	Prevailing Indian Standard as directed by Engineer.	1) TSPS 2) Preliminary Units 3) Sludge Handling Units 4) All Pump House Building
	Monthly		1) Plant Boundary
Noise	Daily	Decibel Meter	1) All process buildings including pump house
	Monthly	Decibel Meter	1) Plant Boundary

The following table explicitly specifies the frequency and method of sampling for various parameters across different process units involved in the reuse system, which are essential for meeting the outlet parameters requirements for reuse, and the contractor shall ensure that all of these parameters shall comply with the quality requirements as specified in the tender document. Refer paragraph 15.20.1.

Parameter	Frequency	Measurement / Sampling Method	Points / Locations
pH	Continuous	Online	1) Outlet of Reuse (UF)
	Daily	Grab sample	1) Outlet of Reuse (GLR)
Turbidity	Continuous	Online	1) Outlet of Reuse (UF)
	Daily	Grab sample	1) Outlet of Reuse (GLR)
TDS	Continuous	Online	1) Outlet of Reuse (UF)
	Daily	Grab sample	1) Outlet of Reuse (GLR)
TSS	Continuous	Online	1) Outlet of Reuse (UF)
	Daily	Grab sample	1) Outlet of Reuse (GLR)
Chlorine	Daily	Grab sample	1) Outlet of Reuse (GLR)
COD	Continuous	Online	1) Outlet of Reuse (UF)
	Daily	Grab sample	1) Outlet of Reuse (GLR)
BOD_5 at 20°C	Continuous	Online	1) Outlet of Reuse (UF)
	Daily	Grab sample	1) Outlet of Reuse (GLR)
Total Nitrogen	Continuous	Online	1) Outlet of Reuse (UF)
	Daily	Grab sample	1) Outlet of Reuse (GLR)
Alkalinity	As needed	Grab sample	1) Outlet of Reuse (GLR)
Total	Continuous	Online	1) Outlet of Reuse (UF)

Parameter	Frequency	Measurement / Sampling Method	Points / Locations
Phosphorus	Daily	Grab sample	1) Outlet of Reuse (GLR)
Fecal Coli-form	Daily	Grab sample	1) Outlet of Reuse (GLR)
Total Coli-form	As needed	Grab sample	1) Outlet of Reuse (GLR)
Temperature	As needed	Grab sample	1) Outlet of Reuse (GLR)
DO	As needed	Grab sample	1) Outlet of Reuse (GLR)
Odour	As needed	Grab sample	1) Outlet of Reuse (GLR)
Color	As needed	Grab sample	1) Outlet of Reuse (GLR)

All costs associated with the sample collection and lab analysis shall be met by the Contractor. The analysis shall be carried out and shall be performed in strict compliance with appropriate analytical methods published in Indian Standards, or in "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, or as published by the US Environmental Protection Agency.

In addition, the Contractor is required to validate its analysis on effluent samples monthly once from an approved laboratory (by Bureau of India Standards), which is not connected to the Project. The validation sampling shall be taken based on Employer decision and the cost of validation/ analysis shall be borne by the Contractor.

During the entire operation and maintenance period, Employer shall nominate their official/counterparts for the inspection of specific WwTP(s) on a weekly basis. Employer shall also nominate a qualified person to carryout periodical inspection of the WwTP(s) and to conduct surprise checks, without prior notice to the Contractor.

Employer shall check the effluent quality of the WwTP(s) every day and instruct the Contractor to undertake appropriate remedial measures, if the performance of the plant is observed as not satisfactory.

Employer shall engage an approved agency (or Bureau of Indian Standards Certified Laboratory) for assessing the effluent quality, for which the samples shall be jointly collected by the Employer (or Bureau of Indian Standards Certified Laboratory) and the Contractor.

In the event of breakdown of the flow-weighted 24-hours composite sample equipment, sampling shall be undertaken manually in a day at every two-hour interval and the results shall be weighted according to flow in order to establish the equivalent daily total load.

The sampling and analysis requirement for the tanker filling station and the potable water system are not explicitly specified in this paragraph. However, it is the contractor's responsibility to ensure that all the quality parameters for these water systems strictly adhere to the required standards before their intended use. To achieve this, the contractor is required to carry out daily tests for tanker filling station and monthly tests for the potable water system, ensuring that all the required quality parameters remain within the prescribed limits for both the tanker filling station and the potable water system.

5.19 Laboratory Information Management System (LIMS)

The proposed works of WwTP shall be provided with Laboratory Information Management System (LIMS) software designed to manage and streamline the operation of the plant laboratory in tracking & managing samples, generating reports, and ensuring compliance with regulations. Here are some key features and functionalities that to be enabled with LIMS software under this contract.

S.No	Feature	Description
1.	Sample Tracking	Tracks the status and location of samples throughout their lifecycle.
2.	Data Management	Organize and manage the data associated with samples, experiments, and tests.
3.	Workflow Management	Automate and standardize laboratory workflows, managing the sequence of tasks.
4.	Instrument Integration	Integrate with laboratory instruments for direct data transfer, reducing manual entry errors.
5.	Sample Storage and Inventory Management	Manage sample storage, tracks sample location, and ensure proper storage conditions.
6.	Audit Trail	Provide a secure and traceable record of all activities within the system.
7.	User Management	Control access to the system, ensuring only authorized personnel can view or modify specific data.
8.	Reporting and Analytics	Generate reports and offer analytical tools for data analysis.
9.	Compliance and Quality Control	Enforce standard operating procedures (SOPs) and aid in compliance with regulations (Like NGT, KSPCB)
10.	Integration with Other Systems	Integrate with laboratory equipment, PLC and SCADA systems.
11.	Mobile Access	Allows user to access information and perform tasks from mobile devices.
12.	Customization	Shall have flexibility to customize the specific need of a laboratory.

Additionally, refer Part 13 of Volume 2, Section 7 of the bid document for specifications and requirement for LIMS software.

5.20 TSPS & WwTPs Design/Sizing Criteria and Other Requirements

Contractor shall submit self-explanatory process design calculations in editable MS-Excel format considering the requirements specified in Part 5 and elsewhere in this Bidding Document. Further contractor shall also submit simulation Model of process design by using BioWin/GPS-X software.

Below Notes are pertaining to design and sizing criteria specified in following tables:

a) All the process unit sizes/volumes specified are minimum.

b) *All the building dimensions (or Area when calculated) specified are minimum; However, Contractor may upsize these dimensions (or Area when calculated) based on design to meet the specified tender requirements.*

c) *While submitting the process design calculation, contractor shall clearly indicate the reference page number and design value as specified in this paragraph (5.20) both during bidding stage and design stage.*

d) *The contractor shall submit the process, civil and mechanical equipment list as indicated in paragraph 15.20.2 and 15.20.3 both during bidding stage and design stage.*

15.20.1 TSPS & WwTPs Design/Sizing Criteria

Item/ Parameter/ Description	Units	WwTP at Channasandra
INFLUENT FLOW AND PROCESS DETAILS		
Contract Package	-	WBS5
WwTP Location	-	Channasandra
Average Flow (For WwTP)	MLD	**20**
Average Flow (For TSPS)	MLD	**20**
Is Industrial Reuse Facilities with GLR and Pump House to be Provided		**YES**
Is Solar PV Power Generation Facilities to be Provided (Refer Volume 2, Section 7, Part 12)		**YES**
This bidding process allows contractors to propose any one of the given secondary treatment processes namely:		EA Process, IFAS Process, MBBR Process, or SBR Process, incorporating biological nitrification, de-nitrification, and phosphorus removal.
Adherence to Proposed Treatment Process		The treatment process proposed by the contractor in accordance with the tender requirements in the bid proposal and accepted by the Engineer must be implemented as per the contract. No changes or alternate process proposals shall be permitted after the award of the contract.
INFLUENT WASTEWATER CHARACTERISTICS		
pH	-	6.5-7.5
BOD	mg/L	350
COD	mg/L	800
TSS	mg/L	450
VSS	mg/L	360
TKN	mg/L	70
NH_4-N	mg/L	45
Total Phosphorus	mg/L	7
Alkalinity	mg/L as $CaCO_3$	370
Min. Sewage Temperature (Tmin)	°C	24
Max. Sewage Temperature (Tmax)	°C	27
Average Elevation above MSL for Process Air Design	m	900
Min. Ambient Temperature	°C	15
Max. Ambient Temperature	°C	45
TREATED EFFLUENT QUALITY REQUIREMENTS - DISCHARGE		
pH - Instantaneous range	-	6.5-8.0
BOD_5 at 20°C - Maximum monthly average	mg/L	10

Item/ Parameter/ Description	Units	WwTP at Channasandra
COD - Maximum monthly average	mg/L	50
TSS - Maximum monthly average	mg/L	10
TN - Maximum monthly average	mg/L	10
Total Phosphorus - Maximum monthly average	mg/L	1
Residual Chlorine - Instantaneous	mg/L	1
Fecal Coliform - Maximum monthly average	MPN/100 mL	100
Fecal Coliform - Ceiling limit (In any day)	MPN/100 mL	230
TREATED EFFLUENT QUALITY REQUIREMENTS FOR REUSE (APPLICABLE AS SPECIFIED)		
Reuse Flow	MLD	10
Turbidity	NTU	< 2.0
SS	mg/L	As arising
TDS	mg/L	< 1000
pH	-	6.5-8.5
Temperature	°C	Ambient
Oil & Grease	mg/L	Nil
TN	mg/L	< 5.0
BOD_5 at 20°C	mg/L	< 5.0
COD	mg/L	< 30.0
TP	mg/L	< 1.0
Residual Cl	mg/L	~1.0
Fecal Coliform	MPN/100mL	Nil
Color	-	Colorless
Odour	-	No foul odour
SLUDGE QUALITY REQUIREMENTS (AFTER CENTRIFUGE)		
Sludge Quality	-	Undigested dewatered sludge
Minimum Solid Concentration in Dewatered Sludge	%	20
NOISE LEVELS		
Noise Levels inside the Process Buildings (Maximum)	dBA	80
Noise Levels at Plant Boundary (Maximum)	dBA	60
WwTP HYDRAULIC CONDITIONS		
Receiving water body	-	Refer Part 1
Receiving water body high flood level	m	Refer Part 1
Minimum positive free fall of treated effluent of WwTP from outfall structure to HFL of receiving water body	m	0.5
Minimum Finished Ground Level (FGL) of WwTP	m	Minimum 0.75m above the HFL
Finished Floor Level (FFL) of WwTP	-	0.5m above FGL
Height of MCC Panel Pedestal	-	0.25m above FFL
Cable Entry to Electrical Panels	-	Top Entry
Lowest Invert level of incoming Gravity Sewer at TSPS inlet chamber…..m below the existing road level	m	6.5
Minimum Free fall lowest invert level of incoming pipe	m	0.1

Item/ Parameter/ Description	Units	WwTP at Channasandra
in Inlet chamber of TSPS to downstream high high water level in TSPS Inlet Chamber		
Minimum Free fall from raft level of Coarse Screen Effluent Channel to downstream high high water level in wet well	m	0.3
TSPS		
Average Flow (For TSPS)	MLD	20
Peak Factor	-	2.25
Peak Flow	m3/h	1875
TSPS INLET CHAMBER WITH SOLID GRAB MECHANISM		
Type	-	Rectangular or Tapered
MOC of Inlet Chamber Structure	-	RCC - M30
Number of units	Nos	1
Flow to each unit	-	Designed for Peak Flows
HRT at Peak flow	s	30
Height of Structure above FGL	m	0.75
TRASH SCREENS AND CHANNELS		
MOC of Channels Structure	-	RCC - M30
Screen type	-	J-type Manual Coarse Bar Screen
MOC of Trash Screen Mechanism	-	SS 316L
No of Units - Working	Nos	1
No of Units - Standby	Nos	1
Design flow per unit	m3/s	Designed for Peak Flows
Angle of inclination of screen	deg.	90
Width to SWD ratio (Width/SWD)	-	1.5 to 2
Maximum Velocity through screen openings at peak flow	m/s	0.9
Clear spacing between bars	mm	50
Minimum bar thickness	mm	20
Bar cross-section	-	Rectangular
Maximum headloss across screen	mm	200
Screening generation rate	m3/mL	0.05
Minimum length of the screen channel on U/S of Trash Screens	-	1.5 times the width of channel
Flow isolation	-	Through isolation gates at U/S. Trash screens and coarse screen are provided in series in a single channel followed by D/S Isolation gate
Height of Structure above FGL	m	0.75
Motorized Monorail Hoist for Trash Screen with Cross Travel & Lift	MT	2
COARSE SCREENS AND CHANNELS		
MOC of Channels Structure	-	RCC - M30
Screen type	-	Multirake type bar screen with mechanical

Item/ Parameter/ Description	Units	WwTP at Channasandra
		cleaning and auto jam removal
MOC of Coarse Screen Mechanism	-	SS 316L
No of Units - Working	Nos	1
No of Units - Standby	Nos	1
Design flow per unit	m3/s	Designed for Peak Flows
Angle of inclination of screen	deg.	75
Width to SWD ratio (Width/SWD)	-	1.5 to 2
Maximum Velocity through screen openings at peak flow	m/s	0.9
Clear spacing between bars	mm	20
Minimum bar thickness	mm	12
Bar cross-section	-	Trapezoidal
Maximum headloss across screen	mm	300
Screening generation rate	m3/mL	0.04
Screening Conveyor with Screening Compactor	-	Shaft Type Helical Screw with MOC: SS 316L
2 m3 Capacity Screen Container (Covered Hydraulic Tractor Trailer)	Nos	2
Flow isolation	-	Through isolation gates at U/S. Trash screens and coarse screen are provided in series in a single channel followed by D/S Isolation gate
Minimum length between D/S of trash screen and U/S of Coarse Screen	-	2.5 times the width of channel
Minimum operating clearance between Screening Conveyor to D/S isolation gate of coarse screen channel	m	1.5
Height of Structure above FGL	m	0.75
COARSE SCREEN EFFLUENT CHANNEL		
Type		Rectangular or Tapered
MOC of Effluent Channel Structure	-	RCC - M30
No of Units	Nos	1
Design flow per unit	-	Designed for Peak Flows
Height of Structure above FGL	m	0.75
Minimum length along flow direction	m	1.5
Flow entry to compartment of TSPS wet well	-	Through Individual Isolation Gates.
PUMPING STATION (WET WELL)		
MOC of Wet Well Structure	-	RCC - M30
Flow to wet well	m3/min	Designed for Peak Flows
No of Compartments in each wet wells	Nos	2
Operating Liquid Depth (Maximum)	m	2.1
Height of Structure above FGL	m	0.75
HRT at Peak flow	min	5
No of Pumps - Working	Nos	4
No of Pumps - Standby	Nos	2
Type of TSPS Pumps	-	Submersible non-clog solids handling wet

Item/ Parameter/ Description	Units	WwTP at Channasandra
		pit with VFD Control
Each pump capacity	m3/h	Designed for Peak Flows
Motorized Monorail Hoist (TSPS Pump House)	MT	3
Wet Well Plan	-	TSPS wet well plan area and its shape shall be selected such that it shall accommodate the installation of pumps valves and its associated piping and its facilities.
Flow isolation and pump configuration in wet well compartment	-	Common isolation gate shall be provided to connect two compartments of wet well. Velocity through isolation gate shall not be more than 0.6 m/s at peak flow condition. All pumps including standby shall be equally installed in each compartment.
No of dewatering pumps - Working	Nos	2
No of dewatering pumps - Standby	Nos	2
Capacity of each dewatering pump	m3/h	Shall be sized to dewater the wetwell volume in less than 2 Hrs
Type of dewatering pump		Submersible
TSPS PUMP HOUSE BUILDING (ABOVE WETWELL)		
Location	-	Above Wet Well
MOC of Structure	-	RCC Framed Structure - M30
Area	-	Same as complete plan area of wetwell
Height (from FFL to bottom of roof beam)	m	5
VALVE CHAMBER		
Number of Chambers	Nos	1
MOC of Structure	-	RCC - M30
Height of the Valve Chamber (Total)	m	2
Height of the Valve Chamber (Above FGL)	m	0.5
WwTP		
Average Flow	MLD	20
Peak Factor	-	2.25
Peak Flow	m3/h	1875
PRELIMINARY TREATMENT		
WwTP INLET CHAMBER		
Type	-	Rectangular or Tapered
MOC of Inlet Chamber Structure	-	RCC - M30
Number of units	Nos	1
Design flow per unit	-	Designed for Peak Flows
HRT at peak flow	s	30
Side water depth (Maximum)	m	1.8
Free board	m	0.5
FINE SCREENS AND CHANNELS		
MOC of Channels Structure	-	RCC - M30
Screen type	-	Perforated plate type continuous rotating mechanical screen equipped with auto

Item/ Parameter/ Description	Units	WwTP at Channasandra
		cleaning with spray nozzles and brushes
Drive Mechanism	-	Motorized gear box drive with overload protection and auto reverse on jamming
Installation	-	Complete screening system shall be factory based pre-fabricated single piece system suitable to install in RCC channel
MOC of Complete Screen Mechanism	-	SS 316L
No of Units - Working	Nos	1
No of Units - Standby	Nos	1
Design flow per unit	m3/s	Designed for Peak Flows
Angle of inclination of screen	deg.	75
Width to SWD ratio (Width/SWD)	-	1.5 to 2
Maximum Velocity through screen openings at peak flow	m/s	0.9
Clear opening of screen	mm	4
C/C distance between the holes	mm	8
Screen opening type	-	Precision-drilled or punched circular holes spaced in staggered rows
Maximum opening area of screening plate	%	40
Minimum thickness of screen plate	mm	4
Maximum headloss across screen	mm	300
Screening generation rate	m3/mL	0.045
Screening Conveyor with Screening Compactor	-	Shaft Type Helical Screw with MOC: SS 316L
2 m3 Capacity Screen Container (Covered Hydraulic Tractor Trailer)	Nos	2
Flow isolation	-	Through isolation gates at both U/S and D/S end of each screen channel
Clear Length of the screen channel on U/S	-	3 times the width of channel
Minimum operating clearance between Screening Conveyor to D/S isolation gate of fine screen channel	m	1.5
Width of walkway between two screen channel	m	1.2
Free board	m	0.5
FINE SCREEN EFFLUENT CHANNEL		
Type	-	Rectangular or Tapered
MOC of Effluent Channel Structure	-	RCC - M30
No of Units	Nos	1
Design flow per unit	m3/s	Designed for Peak Flows including recycle flows
Minimum length along flow direction	m	1.5
Free Board	m	0.5
GRIT CHAMBER		
MOC of Grit Channel Structure	-	RCC - M30
Grit Chamber Type	-	Vortex grit system (With Grit withdrawal, Dedicated washing & grit discharge conveying mechanism)

Item/ Parameter/ Description	Units	WwTP at Channasandra
Design flow per unit	-	Designed for Peak Flows including recycle flows
MOC of Grit Mechanism	-	SS 316L
No of grit chambers Working	Nos	1
Number of grit chambers Standby	Nos	1
Grit generation rate	m3/mL	0.15
Maximum organic content in disposable grit	%	3
Minimum grit removal rate	%	90
Free board	m	0.5
Flow isolation	-	Through isolation gates at both U/S and D/S end of each grit chamber
Grit Discharge Conveyor	-	Shaft Type Helical Screw (1W+ 1S)
Minimum Screw Conveyor Diameter	mm	300
Type of Grit Transfer Pump	-	Vertical non-clog slurry Pump (1W+ 1S)
3 m3 Capacity Screen Container (Covered Hydraulic Tractor Trailer)	Nos	3
PARSHALL FLUME CHANNEL		
Requirement	-	Flow measurement through parshall flume
MOC of Parshall Flume Channel Structure	-	RCC - M30
No of Units	Nos	1
Design flow per unit	-	Designed for Peak Flows including recycle flows
Width to SWD ratio of parshall flume channel (Width/SWD)	-	1.5 to 2
Free Board	m	0.5
Total length of parshall flume channel (Minimum)	m	15
Design of Parshall Flume	-	As per IS Code
Parshall Flume type	-	Prefabricated parshall flume Section Suitable to install in RCC Channel
MOC of Prefabricated parshall flume Section		MOC: SS 316 with thickness of 8mm. (Converging portion, throat portion and diverging portion with Height up to free board of RCC Channel)
SECONDARY TREATMENT		
EXTENDED AERATION (EA)		
MOC of Structure	-	RCC - M30
Process Type	-	Extended Aeration Process with Biological Nutrient Removal. (Nitrification, De-nitrification, and Phosphorus Removal)
Design Flow	-	Shall include peak flow, recycle flows, RAS flows and MLR flows
Tank Geometry	-	Process tank geometry for (Anaerobic-Anoxic-Aerobic) shall be rectangular with flow distribution box and Inlet & outlet channels. Inside configuration of the rectangular tank shall be such that it shall create pass flow to meet the design

Item/ Parameter/ Description	Units	WwTP at Channasandra
		condition as specified including efficient removal of the scum.
Scum Collection	-	Each tank shall be provided with dedicated Scum skimmer (Helical type / Rotating pipe type) which shall operate to remove surface scum and floatable material from anaerobic zone, anoxic zone and aerobic zone
N-1 condition	-	The Bidder shall provide calculations for operating the WwTP at Design Flows with 1 tank/unit/module offline for maintenance.
Interfaces between anaerobic-to-anoxic zones.		concrete partition walls that serve as overflow weirs
Interfaces between anoxic-to-aerobic zone		concrete partition walls that serve as overflow weirs
anaerobic-to-anaerobic sub-zones Interfaces		Concrete baffle walls designed to provide side-to-side long plug flow conditions within the zones
anoxic-to-anoxic sub-zones Interfaces		Concrete baffle walls designed to provide side-to-side long plug flow conditions within the zones
aerobic-to-aerobic sub-zones Interfaces		No physical baffle wall is required. However, each aerobic sub-zone shall have a separate diffuser grid supplied by a separate air drop pipe with the air flow controlled by a separate valve and measured by a separate flow meter.
Outlet flow from Aerobic zone to outlet channel		Through overflow weir.
Flow from Aerobic zone to De-aeration zone for MLR pumps		Through overflow weir.
Flow from Anoxic to Aerobic Zone		Submerged weir with maximum 100 mm headloss under all operating and hydraulic conditions
Flow from Anaerobic to Anoxic zone		Submerged weir with maximum 100 mm headloss under all operating and hydraulic conditions
Inlet flow distribution	-	Through flow distribution box equipped with weir plate for equal flow distribution to each tank. Each weir shall be followed by isolation gate to each tank.
RAS and MLR Flows		Both RAS and MLR flows shall be routed directly to the appropriate individual basin zone and shall not be brought into the inlet distribution/Influent Channel. MLR flows shall be routed to the beginning of the anoxic zone. Whilst RAS flows shall by default be routed to the beginning of the anaerobic zone.
Maximum MLVSS/MLSS ratio	-	0.7
NH4-N (Maximum)	mg/L	1
Flow Distribution Box		
Type	-	Rectangular

Item/ Parameter/ Description	Units	WwTP at Channasandra
Number of units	Nos	1
Design flow per unit	-	Designed for Peak Flows including recycle flows
HRT at peak flow	s	45
Free board	m	0.5
Overall Tank Dimensions		
Total HRT at average flow (Anaerobic+Anoxic+Aerobic+Deaeration)	Hrs	21
HRT Fraction of Anaerobic Zone to Total HRT	%	6% to 8%
HRT Fraction of Anoxic Zone to Total HRT	%	20% to 25%
HRT Fraction of Aerobic Zone to Total HRT	%	65% to 70%
HRT Fraction of Deaeration Zone to Total HRT	%	2% to 4%
No of Tanks - Working	Nos	2
Side water depth (Maximum)	m	6
Free board	m	0.6
Type of mixing for both Anaerobic and Anoxic Zone	-	Mechanical
Mixer Type	-	Submersible
Minimum unit power input for mixing	W/m3	10
No of Sub Zones for Anaerobic Zone	Nos	2
No of Sub Zones for Anoxic Zone	Nos	4
No of Sub Zones for Aerobic Zone	Nos	4
No of mixers in each sub zone of anaerobic and anoxic zone	Nos	1
SRT	Days	As per Vendor Design.
F/M	-	As per Vendor Design.
MLSS	mg/L	As per Vendor Design.
Aeration Basin Effluent Channel (Inside not allowed, shall be placed outside the aeration basin)		
No of Units	Nos	1
Design flow per unit	-	Designed for Peak Flows including recycle and RAS flows
Width to SWD ratio of channel (Width/SWD)	-	2
Free Board	m	0.5
MLR Pumps		
MLR Ratio at average flow	Times	4.5
No of working MLR pumps in each de-aeration zone	Nos	1
No of standby MLR pumps in each de-aeration zone	Nos	1
Type and location of MLR Pump	-	Submersible or Tube Installed pumps located in de-aeration zone with VFD Control
Capacity of Fully EOT (LT,CT,Lift) (3 drives) Crane for MLR pumps (1 No)	MT	3
Design Flexibility for MLR Pumping		Design shall provide to route 100% of MLR to anoxic zones and flexibility to route up to 50% to the anaerobic zones.

Item/ Parameter/ Description	Units	WwTP at Channasandra
De-aeration zone		
No of Tanks - Working	Nos	2
Flow to De-aeration zone		MLSS over flow from aeration tank
Side water depth (Maximum)	m	5.7
Free board	m	0.6
Type of mixing in de-aeration zone	-	Mechanical
Mixer Type	-	Submersible
Minimum unit power input for mixing	W/m3	10
No of mixers	Nos	2
SECONDARY CLARIFIERS (EA PROCESS)		
MOC of Secondary Clarifiers Structure		RCC - M30
Inlet flow distribution		Through flow distribution box equipped with weir plate for equal flow distribution to each clarifier. Each weir shall be followed by isolation gate to each clarifier.
Type of clarifier		Circular, center-column supported with center drive, and center feed. Peripheral drive or bridge-supported not allowed.
Sludge scraper		4-arm spiral sludge scraper - two full-radius arms and two 1/3rd radius arms. Center sludge hopper sized per most rigorous published criteria.
Scum Collection and removal		Full-radius scum baffle with beach-type skimmer.
Type of sludge withdrawal system from clarifier		Through sludge pipe coupled with dedicated RAS pump.
Design Flexibility for RAS Pumping		Design shall provide to route 100% of RAS to each anaerobic zones and flexibility to route up to 50% to the each anoxic zones. Such flexibility shall be achieved by providing motorized eccentric plug valve to each anaerobic and anoxic zone of each tank.
Sludge withdrawal piping		No two clarifier sludge withdrawal pipe shall be hydraulically connected to each other. This shall also ensure while switching from working to standby operation.
Type of sludge wasting (WAS) from clarifier		Tapping from main RAS line with motorized eccentric plug valve
Bottom slope of clarifier	1 in	12
Outlet Launders		Double sided launders are not allowed
density currents in the clarifier		A “Stamford” type RCC baffle of 45 degrees inclination shall be provided in secondary clarifier to deflect the density currents towards the center of clarifier and away from outlet launder.
Secondary Clarifier Flow Distribution Box		
Type	-	Rectangular
Number of units	Nos	1

Item/ Parameter/ Description	Units	WwTP at Channasandra
Design flow per unit	-	Designed for Peak Flows including recycle and RAS flows
HRT at peak flow	s	45
Free board	m	0.5
Clarifiers Sizing		
Number of clarifiers	Nos	2
SWD	m	3.7
Free board	m	0.5
Calculated Maximum SOR at Average flow	m3/m2/day	15
Calculated Maximum Solid Loading Rate at Peak Flow (Including RAS)	kg/m2/day	180
Under Flow (RAS)		
Ratio of Under Flow to Over flow @average	times	1
Total No of RAS pumps-working	Nos	2
Total No of RAS pumps-standby	Nos	1
Type of RAS Pump	-	Horizontal or Vertical Centrifugal solid handling dry pit pump with VFD Control
Capacity of Fully EOT (LT,CT,Lift) (3 drives) Crane for RAS pumps (1 No)	MT	2
Clarifier Feed Well		
Percentage of diameter of clarifier considered for feed well	%	18
Maximum velocity through central column shaft (At peak flow including RAS flows)	m/s	0.6
Maximum velocity through inlet port	mm/s	200
Clarifier Outlet launders		
Width of clarifier outlet launder (Minimum)	m	0.7
SECONDARY PUMP HOUSE (EA PROCESS)		
Number of Building	Nos	1
Number of Floors	Nos	Ground Floor
MOC of Structure		RCC Framed Structure - M30
Length	m	10
Width	m	9
Height (from FFL to bottom of roof beam)	m	5
INTEGRATED FIXED-FILM ACTIVATED SLUDGE (IFAS)		
MOC of Structure	-	RCC - M30
Process Type	-	Integrated Fixed-film Activated Sludge (IFAS) Process with Biological Nutrient Removal. (Nitrification, De-nitrification, and Phosphorus Removal)
Design Flow	-	Shall be designed to include peak flow, recycle flows, RAS flows and MLR flows
Tank Geometry	-	Process tank geometry for IFAS (Anaerobic-Anoxic-Aerobic) shall be rectangular with flow distribution box and

Item/ Parameter/ Description	Units	WwTP at Channasandra
		Inlet & outlet channels. Inside configuration of the rectangular tank shall be such that it shall create pass flow to meet the design condition as specified including efficient removal of the scum.
Scum Collection	-	Each IFAS tank shall be provided with dedicated Scum skimmer (Helical type / Rotating pipe type) which shall operate to remove surface scum and floatable material from anaerobic zone, anoxic zone and aerobic zone
N-1 condition	-	The Bidder shall provide calculations for operating the WwTP at Design Flow with 1 IFAS tank/unit/module offline for maintenance.
Interfaces between anaerobic-to-anoxic zones.		concrete partition walls that serve as overflow weirs
Interfaces between anoxic-to-aerobic zone		concrete partition walls that serve as overflow weirs
anaerobic-to-anaerobic sub-zones Interfaces		Concrete baffle walls designed to provide side-to-side long plug flow conditions within the zones
anoxic-to-anoxic sub-zones Interfaces		Concrete baffle walls designed to provide side-to-side long plug flow conditions within the zones
aerobic-to-aerobic sub-zones Interfaces		No physical baffle wall is required. However, each aerobic sub-zone shall have a separate diffuser grid supplied by a separate air drop pipe with the air flow controlled by a separate valve and measured by a separate flow meter.
Outlet flow from Aerobic zone to outlet channel		Through overflow weir.
Flow from Aerobic zone to De-aeration zone for MLR pumps		Through overflow weir.
Flow from Anoxic to Aerobic Zone		Submerged weir with maximum 100 mm headloss under all operating and hydraulic conditions
Flow from Anaerobic to Anoxic zone		Submerged weir with maximum 100 mm headloss under all operating and hydraulic conditions
Inlet flow distribution	-	Through flow distribution box equipped with weir plate for equal flow distribution to each tank. Each weir shall be followed by isolation gate to each tank.
RAS and MLR Flows		Both RAS and MLR flows shall be routed directly to the appropriate individual basin zone and shall not be brought into the inlet distribution/Influent Channel. MLR flows shall be routed to the beginning of the anoxic zone. Whilst RAS flows shall by default be routed to the beginning of the anaerobic zone.
Maximum MLVSS/MLSS ratio	-	0.7

Item/ Parameter/ Description	Units	WwTP at Channasandra
NH4-N (Maximum)	mg/L	1
Flow Distribution Box		
Type	-	Rectangular
Number of units	Nos	1
Design flow per unit	-	Designed for Peak Flows including recycle flows
HRT at peak flow	s	45
Free board	m	0.5
Overall Tank Dimensions		
Total HRT at average flow (Anaerobic+Anoxic+Aerobic+Deaeration)	Hrs	18
HRT Fraction of Anaerobic Zone to Total HRT	%	6% to 10%
HRT Fraction of Anoxic Zone to Total HRT	%	25% to 30%
HRT Fraction of Aerobic Zone (Including IFAS) to Total HRT	%	55% to 65%
HRT Fraction of Deaeration Zone to Total HRT	%	3% to 6%
No of Tanks - Working	Nos	2
Side water depth (Maximum)	m	6
Free board	m	0.6
Type of mixing for both Anaerobic and Anoxic Zone	-	Mechanical
Mixer Type	-	Submersible
Minimum unit power input for mixing	W/m3	10
No of Sub Zones for Anaerobic Zone	Nos	2
No of Sub Zones for Anoxic Zone	Nos	4
No of Sub Zones for Aerobic Zone	Nos	4
No of mixers in each sub zone of anaerobic and anoxic zone	Nos	1
SRT	Days	As per Vendor Design.
F/M	-	As per Vendor Design.
MLSS	mg/L	As per Vendor Design.
IFAS Basin Effluent Channel (Inside not allowed, shall be placed outside the aeration basin)		
No of Units	Nos	1
Design flow per unit	-	Designed for Peak Flows including recycle and RAS flows
Width to SWD ratio of channel (Width/SWD)	-	2
Free Board	m	0.5
MLR Pumps		
MLR Ratio at average flow	Times	4.5
No of working MLR pumps in each de-aeration zone	Nos	1
No of standby MLR pumps in each de-aeration zone	Nos	1
Type and location of MLR Pump	-	Submersible or Tube Installed pumps located in de-aeration zone with VFD Control

Item/ Parameter/ Description	Units	WwTP at Channasandra
Capacity of Fully EOT (LT,CT,Lift) (3 drives) Crane for MLR pumps (1 No)	MT	3
Design Flexibility for MLR Pumping		Design shall provide to route 100% of MLR to anoxic zones and flexibility to route up to 50% to the anaerobic zones.
De-aeration zone		
No of Tanks - Working	Nos	2
Flow to De-aeration zone		MLSS over flow from aeration tank
Side water depth (Maximum)	m	5.7
Free board	m	0.6
Type of mixing in de-aeration zone	-	Mechanical
Mixer Type	-	Submersible
Minimum unit power input for mixing	W/m3	10
No of mixers	Nos	2
IFAS Media		
Media Type	-	Submerged high-density bio-textile media in SS 316 cages.
Media Life (Minimum)	years	20
Media Placement/Zone Design	-	Mostly, IFAS media shall be placed in middle two-third of the aerobic zone (Staggered arrangement). And no media shall be placed in last one-fourth of the aerobic zone.
Media retention system	-	Fixed media caged in 6 mm thick SS 316 frame.
Void Fraction (Portion of the media volume that is unoccupied)	%	90
Media Density	g/cm³	0.96 - 0.98 (slightly submerged).
Solid Loading Rate on IFAS Media (Maximum)	g/m²	45
Effective area of IFAS media (Maximum)	%	65
Spare Media (Minimum)	%	5
Aeration and mixing requirement	-	Fine bubble diffusers for mixing, oxygenation, prevent dead zones
SECONDARY CLARIFIERS (IFAS PROCESS)		
MOC of Secondary Clarifiers Structure		RCC - M30
Inlet flow distribution		Through flow distribution box equipped with weir plate for equal flow distribution to each clarifier. Each weir shall be followed by isolation gate to each clarifier.
Type of clarifier		Circular, center-column supported with center drive, and center feed. Peripheral drive or bridge-supported not allowed.
Sludge scraper		4-arm spiral sludge scraper - two full-radius arms and two 1/3rd radius arms. Center sludge hopper sized per most rigorous published criteria.
Scum Collection and removal		Full-radius scum baffle with beach-type skimmer.

Item/ Parameter/ Description	Units	WwTP at Channasandra
Type of sludge withdrawal system from clarifier		Through sludge pipe coupled with dedicated RAS pump.
Design Flexibility for RAS Pumping		Design shall provide to route 100% of RAS to each anaerobic zones and flexibility to route up to 50% to the each anoxic zones. Such flexibility shall be achieved by providing motorized eccentric plug valve to each anaerobic and anoxic zone of each tank.
Sludge withdrawal piping		No two clarifier sludge withdrawal pipe shall be hydraulically connected to each other. This shall also ensure while switching from working to standby operation.
Type of sludge wasting (WAS) from clarifier		Tapping from main RAS line with motorized eccentric plug valve
Bottom slope of clarifier	1 in	12
Outlet Launders		Double sided launders are not allowed
density currents in the clarifier		A “Stamford” type RCC baffle of 45 degrees inclination shall be provided in secondary clarifier to deflect the density currents towards the center of clarifier and away from outlet launder.
Secondary Clarifier Flow Distribution Box		
Type	-	Rectangular
Number of units	Nos	1
Design flow per unit	-	Designed for Peak Flows including recycle and RAS flows
HRT at peak flow	s	45
Free board	m	0.5
Clarifiers Sizing		
Number of clarifiers	Nos	2
SWD	m	3.7
Free board	m	0.5
Calculated Maximum SOR at Average flow	m3/m2/day	15
Calculated Maximum Solid Loading Rate at Peak Flow (Including RAS)	kg/m2/day	180
Under Flow (RAS)		
Ratio of Under Flow to Over flow @average	times	1
Total No of RAS pumps-working	Nos	2
Total No of RAS pumps-standby	Nos	1
Type of RAS Pump	-	Horizontal or Vertical Centrifugal solid handling dry pit pump with VFD Control
Capacity of Fully EOT (LT,CT,Lift) (3 drives) Crane for RAS pumps (1 No)	MT	2
Clarifier Feed Well		
Percentage of diameter of clarifier considered for feed well	%	18
Maximum velocity through central column shaft (At	m/s	0.6

Item/ Parameter/ Description	Units	WwTP at Channasandra
peak flow including RAS flows)		
Maximum velocity through inlet port	mm/s	200
Clarifier Outlet launders		
Width of clarifier outlet launder (Minimum)	m	0.7
SECONDARY PUMP HOUSE (IFAS PROCESS)		
Number of Building	Nos	1
Number of Floors	Nos	Ground Floor
MOC of Structure		RCC Framed Structure - M30
Length	m	10
Width	m	9
Height (from FFL to bottom of roof beam)	m	5
MOVING BED BIOFILM REACTOR (MBBR)		
MOC of Structure	-	RCC - M30
Process Type	-	Moving Bed Biofilm Reactor (MBBR) Process with Biological Nutrient Removal. (Nitrification, De-nitrification, and Phosphorus Removal)
Design Flow	-	Shall be designed to include peak flow, recycle flows, RAS flows and MLR flows
Tank Geometry	-	Process tank geometry for MBBR (Anaerobic-Anoxic-MBBR-Aerobic) shall be rectangular with flow distribution box and Inlet & outlet channels. Inside configuration of the rectangular tank shall be such that it shall create pass flow to meet the design condition as specified including efficient removal of the scum.
Scum Collection	-	Each MBBR tank shall be provided with dedicated Scum skimmer (Helical type / Rotating pipe type) which shall operate to remove surface scum and floatable material from anaerobic zone, anoxic zone, MBBR zone and aerobic zone
N-1 condition	-	The Bidder shall provide calculations for operating the WwTP at Design Flow with 1 MBBR tank/unit/module offline for maintenance.
Interfaces between anaerobic-to-anoxic zones.		concrete partition walls that serve as overflow weirs
Interfaces between anoxic-to-MBBR zone		concrete partition walls that serve as overflow weirs
Interfaces between MBBR-to-aerobic zone		concrete partition walls that serve to provide screens to retain MBBR media
anaerobic-to-anaerobic sub-zones Interfaces		Concrete baffle walls designed to provide side-to-side long plug flow conditions within the zones
anoxic-to-anoxic sub-zones Interfaces		Concrete baffle walls designed to provide side-to-side long plug flow conditions within the zones

Item/ Parameter/ Description	Units	WwTP at Channasandra
aerobic-to-aerobic sub-zones Interfaces		No physical baffle wall is required. However, each aerobic sub-zone shall have a separate diffuser grid supplied by a separate air drop pipe with the air flow controlled by a separate valve and measured by a separate flow meter.
Outlet flow from Aerobic zone to outlet channel		Through overflow weir.
Flow from Aerobic zone to De-aeration zone for MLR pumps		Through overflow weir.
Flow from MBBR zone to Aerobic Zone		Submerged media retain screens with maximum 100 mm headloss under all operating and hydraulic conditions
Flow from Anoxic to MBBR Zone		Submerged weir with maximum 100 mm headloss under all operating and hydraulic conditions
Flow from Anaerobic to Anoxic zone		Submerged weir with maximum 100 mm headloss under all operating and hydraulic conditions
Inlet flow distribution	-	Through flow distribution box equipped with weir plate for equal flow distribution to each tank. Each weir shall be followed by isolation gate to each tank.
RAS and MLR Flows		Both RAS and MLR flows shall be routed directly to the appropriate individual basin zone and shall not be brought into the inlet distribution/Influent Channel. MLR flows shall be routed to the beginning of the anoxic zone. Whilst RAS flows shall by default be routed to the beginning of the anaerobic zone.
Maximum MLVSS/MLSS ratio	-	0.7
NH4-N (Maximum)	mg/L	1
Flow Distribution Box		
Type	-	Rectangular
Number of units	Nos	1
Design flow per unit	-	Designed for Peak Flows including recycle flows
HRT at peak flow	s	45
Free board	m	0.5
Overall Tank Dimensions		
Total HRT at average flow (Anaerobic+Anoxic+MBBR+Aerobic+Deaeration)	Hrs	18
HRT Fraction of Anaerobic Zone to Total HRT	%	6% to 10%
HRT Fraction of Anoxic Zone to Total HRT	%	25% to 30%
HRT Fraction of Aerobic Zone (including MBBR) to Total HRT	%	55% to 65%
HRT Fraction of Deaeration Zone to Total HRT	%	3% to 6%
No of Tanks - Working	Nos	2
Side water depth (Maximum)	m	6

Item/ Parameter/ Description	Units	WwTP at Channasandra
Free board	m	0.6
Type of mixing for both Anaerobic and Anoxic Zone	-	Mechanical
Mixer Type	-	Submersible
Minimum unit power input for mixing	W/m3	10
No of Sub Zones for Anaerobic Zone	Nos	2
No of Sub Zones for Anoxic Zone	Nos	4
No of Sub Zones for Aerobic Zone	Nos	4
No of mixers in each sub zone of anaerobic and anoxic zone	Nos	1
SRT	Days	As per Vendor Design.
F/M	-	As per Vendor Design.
MLSS	mg/L	As per Vendor Design.
MBBR Basin Effluent Channel (Inside not allowed, shall be placed outside the aeration basin)		
No of Units	Nos	1
Design flow per unit	-	Designed for Peak Flows including recycle and RAS flows
Width to SWD ratio of channel (Width/SWD)	-	2
Free Board	m	0.5
MLR Pumps		
MLR Ratio at average flow	Times	4.5
No of working MLR pumps in each de-aeration zone	Nos	1
No of standby MLR pumps in each de-aeration zone	Nos	1
Type and location of MLR Pump	-	Submersible or Tube Installed pumps located in de-aeration zone with VFD Control
Capacity of Fully EOT (LT,CT,Lift) (3 drives) Crane for MLR pumps (1 No)	MT	3
Design Flexibility for MLR Pumping		Design shall provide to route 100% of MLR to anoxic zones and flexibility to route up to 50% to the anaerobic zones.
De-aeration zone		
No of Tanks - Working	Nos	2
Flow to De-aeration zone		MLSS over flow from aeration tank
Side water depth (Maximum)	m	5.7
Free board	m	0.6
Type of mixing in de-aeration zone	-	Mechanical
Mixer Type	-	Submersible
Minimum unit power input for mixing	W/m3	10
No of mixers	Nos	2
MBBR Media		
Media Type	-	Virgin HDPE biofilm carrier media, cylindrical with internal fins/spokes.
Media Life (Minimum)	years	20
Media Placement/Zone Design	-	Dedicated MBBR zone with coarse-bubble

Item/ Parameter/ Description	Units	WwTP at Channasandra
		diffusers for uniform mixing, with maximum fill fraction 50% of MBBR tank volume.
Media retention system	-	6 mm thick SS 316 screens for media containment, with maximum 100 mm head loss.
Void Fraction (Portion of the media volume that is unoccupied)	%	80
Media Density	g/cm^3	0.96 - 0.98 (slightly buoyant).
Solid Loading Rate on MBBR Media (Maximum)	g/m^2	45
Maximum Effective Surface Area of MBBR media	m^2/m^3	500
Spare Media (Minimum)	%	5
Maximum ratio of MBBR tank volume to Aerobic tank volume (MBBR Tank/Aerobic Tank)	-	1
Aeration and mixing in MBBR tank	-	Coarse bubble diffusers for mixing, oxygenation, prevent clumping, uniform media distribution in MBBR tank.
SECONDARY CLARIFIERS (MBBR PROCESS)		
MOC of Secondary Clarifiers Structure		RCC - M30
Inlet flow distribution		Through flow distribution box equipped with weir plate for equal flow distribution to each clarifier. Each weir shall be followed by isolation gate to each clarifier.
Type of clarifier		Circular, center-column supported with center drive, and center feed. Peripheral drive or bridge-supported not allowed.
Sludge scraper		4-arm spiral sludge scraper - two full-radius arms and two 1/3rd radius arms. Center sludge hopper sized per most rigorous published criteria.
Scum Collection and removal		Full-radius scum baffle with beach-type skimmer.
Type of sludge withdrawal system from clarifier		Through sludge pipe coupled with dedicated RAS pump.
Design Flexibility for RAS Pumping		Design shall provide to route 100% of RAS to each anaerobic zones and flexibility to route up to 50% to the each anoxic zones. Such flexibility shall be achieved by providing motorized eccentric plug valve to each anaerobic and anoxic zone of each tank.
Sludge withdrawal piping		No two clarifier sludge withdrawal pipe shall be hydraulically connected to each other. This shall also ensure while switching from working to standby operation.
Type of sludge wasting (WAS) from clarifier		Tapping from main RAS line with motorized eccentric plug valve
Bottom slope of clarifier	1 in	12
Outlet Launders		Double sided launders are not allowed
density currents in the clarifier		A “Stamford” type RCC baffle of 45

Item/ Parameter/ Description	Units	WwTP at Channasandra
		degrees inclination shall be provided in secondary clarifier to deflect the density currents towards the center of clarifier and away from outlet launder.
Secondary Clarifier Flow Distribution Box		
Type	-	Rectangular
Number of units	Nos	1
Design flow per unit	-	Designed for Peak Flows including recycle and RAS flows
HRT at peak flow	s	45
Free board	m	0.5
Clarifiers Sizing		
Number of clarifiers	Nos	2
SWD	m	3.7
Free board	m	0.5
Calculated Maximum SOR at Average flow	m3/m2/day	15
Calculated Maximum Solid Loading Rate at Peak Flow (Including RAS)	kg/m2/day	180
Under Flow (RAS)		
Ratio of Under Flow to Over flow @average	times	1
Total No of RAS pumps-working	Nos	2
Total No of RAS pumps-standby	Nos	1
Type of RAS Pump	-	Horizontal or Vertical Centrifugal solid handling dry pit pump with VFD Control
Capacity of Fully EOT (LT,CT,Lift) (3 drives) Crane for RAS pumps (1 No)	MT	2
Clarifier Feed Well		
Percentage of diameter of clarifier considered for feed well	%	18
Maximum velocity through central column shaft (At peak flow including RAS flows)	m/s	0.6
Maximum velocity through inlet port	mm/s	200
Clarifier Outlet launders		
Width of clarifier outlet launder (Minimum)	m	0.7
SECONDARY PUMP HOUSE (MBBR PROCESS)		
Number of Building	Nos	1
Number of Floors	Nos	Ground Floor
MOC of Structure		RCC Framed Structure - M30
Length	m	10
Width	m	9
Height (from FFL to bottom of roof beam)	m	5
SEQUENTIAL BATCH REACTOR (SBR)		
MOC of Structure	-	RCC - M30
Process Type	-	SBR Process with Biological Nutrient Removal. (Nitrification, De-nitrification,

Item/ Parameter/ Description	Units	WwTP at Channasandra
		and Phosphorus Removal)
Is Multi-tier SBR Treatment Process Accepted	-	**NO**
Design Flow	-	SBR tank design shall include peak flow and recycle flows so as no overflow of tanks at any given time. Further, no part of the free board shall be used to accumulate the excess peak flows in SBR tank.
Tank Geometry	-	SBR Tank geometry shall be rectangular or square tanks with efficient removal of the scum and shall capable of collecting the scum with varied water levels of SBR tank.
Scum Collection	-	Each SBR tank shall be provided with dedicated Scum skimmer (Helical type / Adjustable weir type / Rotating pipe type) which shall operate to remove surface scum and floatable material from water level at top decanting level, bottom decanting level and average decanting level of SBR tank and pre-zone or selector zone.
N-1 condition	-	The Bidder shall provide calculations for operating the WwTP at Design Flow with 1 SBR tank offline for maintenance.
Flow Distribution Box		
Type	-	Rectangular
Number of units	Nos	1
Design flow per unit	-	Designed for Peak Flows including recycle flows
HRT at peak flow	s	45
Free board	m	0.5
SBR tanks		
Design flow per unit	-	Designed for Peak Flows including recycle flows
Fill time	Minutes	As per Vendor Design.
Aeration Time	Minutes	As per Vendor Design.
Mixing Time	Minutes	As per Vendor Design.
Minimum Settling Time	Minutes	45
Decanting Time	Minutes	As per Vendor Design.
Sludge Wasting Time	Minutes	As per Vendor Design.
No of Cycles in day	cycles per day	4 or 6 or 8
Maximum Volumetric Inlet BOD Loading Rate to SBR Tanks	kg BOD / m^3. d	**0.35**
Sewage temperature for process parameter design	°C	24
SVI	mL/g	120
Minimum No of SBR Tanks - Working	Nos	4
Side water depth (Maximum)	m	6
Free board (Minimum)	m	0.6
HRT at average flow	Hrs	24
SRT	Days	As per Vendor Design.

Item/ Parameter/ Description	Units	WwTP at Channasandra
F/M	-	As per Vendor Design.
MLSS	mg/L	As per Vendor Design.
Maximum MLVSS/MLSS ratio	-	0.7
NH4-N (Maximum)	mg/L	1
Pre-Zone or Selector Zone (As Applicable)	-	As per Vendor Design.
Type of mixing (As Applicable)	-	Submersible Mechanical Mixer / Mixing with Air.
Mixing with Air	-	For pre-zone or selector zone mixing, dedicated coarse bubble diffuser shall be provided with dedicated flow measurement to each pre-zone or selector zone. Minimum air mixing rate for mixing with air shall be 0.9 m3/h.m3
Submersible Mechanical Mixer	-	If the process cycle includes a fill-mix phase or only mixing phase without aeration, then submersible type mixers shall be provided in each SBR basins. Submersible type mixers shall be provided in each SBR basins for SBR design without pre-zone or selector zone. Minimum unit power input for mechanical submersible mixing shall be 8 to 10 W/m3
Decanter		
SBR Outlet flow	-	Through Decanter.
Decanter Type	-	Floating or electromechanically positioned with subsurface withdrawal and positive solids and scum exclusion mechanism. Fixed decanters or surface withdrawal not allowed.
Decanter Scum Retention	-	Each decanter shall have in-built scum retention mechanism to prevent surface scum and floatable material from exiting with treated effluent.
MOC of Complete Decanter	-	SS 316L
Minimum decanting flow rate of ….times the average flow shall be considered to calculate the decanter weir length in each basin.	-	1.7
Maximum decanting depth shall be calculated based on…	m	Peak flow condition.
Lag time	-	Lag time is not allowed for decanting flow. At any given time, minimum one SBR tank shall be under decanting phase.
Maximum decanter weir loading rate	$m^3/h/m$	120
Minimum No of operating Decanters in each SBR basin	Nos	1
Return Activated Sludge (RAS) Pumps (Optional)		
Minimum RAS Ratio based on average inlet flow to each SBR tank.	%	35
No of RAS pumps in each SBR tank - working	Nos	1
RAS pump capacity	m3/h	As per Vendor Design.
No of RAS pumps in each SBR tank - standby	Nos	1

Item/ Parameter/ Description	Units	WwTP at Channasandra
Total No of RAS pumps -working	Nos	4
Total No of RAS pumps standby	Nos	4
Pump Type	-	Submersible non-clog solids handling wet pit with VFD Control
Waste Activated Sludge (WAS) Pumps		
Minimum Sludge Generation Fraction @ Inlet BOD load	kg / kg	0.82
Maximum Under flow sludge consistency from SBR tank (For WAS Pump Design)	%	0.8
No of WAS pumps in each SBR tank - working	Nos	1
WAS pump capacity	m3/h	As per Vendor Design.
No of WAS pumps in each SBR tank - standby	Nos	1
Total No of WAS pumps -working	Nos	4
Total No of WAS pumps standby	Nos	4
Pump Type	-	Submersible non-clog solids handling wet pit with VFD Control
Motorized Monorail Hoist (1 No in each SBR Tank)	MT	2
Effluent Channel For SBR		
No of Units	Nos	1
Design flow per unit	-	Designed for Peak Flows
Width to SWD ratio of channel (Width/SWD)	-	2
Free Board	m	0.5
PROCESS AIR BLOWERS FOR ALL TREATMENT PROCESSES		
Actual Oxygen Transfer Rate (AOTR)		
Oxygen Requirement for BOD Removal	kg of O2 / kg of BOD	1.2
Oxygen Requirement for Nitrification	kg of O2 / kg of NOx	4.57
Oxygen credit from Denitrification (minus)	kg of O2 / kg of NO3-N	-2.86
Maximum % of Denitrification credit to be considered	%	75
Peak Oxygen Demand Factor on (BOD + Nitrification - 75% of Denitrification)	-	1.3
AOTR	kg/h	AOTR shall be derived by including above specified parameters
Standard Oxygen Transfer Rate (SOTR)		
Average Elevation above MSL for Process Air Design	m	900
Aeration system sizing basis process liquid temperature	°C	27
Aeration Depth	m	For SBR it's a average aeration depth, else SWD of aeration tank.
Minimum DO Level of Aeration basin	mg/L	2
α: Oxygen Transfer Correction Factor	-	0.6
β: Salinity - Surface Tension Correction Factor	-	0.95
F: Fouling Factor	-	0.8
SOTR	kg/h	SOTR shall be derived based on AOTR and

Item/ Parameter/ Description	Units	WwTP at Channasandra
		by including above specified parameters
Blower capacity (at 20°C and 1atm)		
Type of Aeration	-	Diffused Aeration
Centre of diffusers from tank floor	m	0.25
Design SOTE per m depth of water (Minimum to be provided from vendor and maximum to be used as design basis)	% /m	5.5
Minimum Safety factor on blower capacity	-	1.1
Total number of working blowers	Nos	4
Total number of standby blowers	Nos	2
Blower capacity (at 20°C and 1atm)	Nm3/h	Shall be derived based on SOTR and by including above specified parameters
Blower capacity (at field conditions)		
Inlet Humidity for air	%	75
Average Site Elevation	m	900
Ambient air temperature	°C	45
Blower capacity (at field conditions)	m3/h (at Inlet)	Shall be calculated to field conditions by including specified site conditions
blower turndown ratio	%	50
Type of Blower		Centrifugal Turbo Blower with VFD Control
Minimum Thickness of Acoustic Hood	mm	100
Capacity of Fully EOT (LT,CT,Lift) (3 drives) Crane for Blower building (1 No)	MT	5
PROCESS AIR DIFFUSERS FOR ALL TREATMENT PROCESSES		
Type of Aeration	-	Diffused Aeration
Max air flow per effective area of diffuser for design (at 20°C and 1atm)	Nm3/hr/m2	70
Maximum Head loss across single diffuser	mm	350
Diffuser type	-	Fine bubble membrane, tubular or disc
Min % of uninstalled spare diffusers	%	5
Membrane material	-	EPDM or silicone elastomer with UV protection
Type of Diffuser Arrangement	-	Fixed Diffuser Arrangement
BLOWER BUILDING (INCLUDING ELECTRICAL PANEL)		
Number of Building	Nos	1
Number of Floors	Nos	Ground Floor
MOC of Structure		RCC Framed Structure - M30
Length	m	21
Width	m	12
Height of blower room (from FFL to bottom of roof beam)	m	7
Height of blower MCC room (from FFL to bottom of roof beam)	m	5

Item/ Parameter/ Description	Units	WwTP at Channasandra
ALUM MIXER AT DOSING POINT (FOR ALL TREATMENT PROCESSES)		
Type		Turbine
Type of rapid mixing provided for alum	-	In chamber mixing, shall be designed to handle the maximum flow condition.
Minimum unit power input for mixing	W/m3	50
Location	-	D/S of aeration effluent channel
No of Mixers	Nos	1
Minimum HRT of the mixing chamber at peak flow	Sec	30
ALUM DOSING SYSTEM (FOR ALL TREATMENT PROCESSES)		
Design dosing rate (Minimum)	mg/L	12
MOC of Dosing Tank	-	GRP or HDPE
Total No of Dosing Tanks	Nos	2
Volume provided	Hrs	Each tank shall be sized to hold 12Hrs of Alum Solution based on design dosing rate and concentration
Free board	m	0.5
Type of mixing for alum dosing tanks	-	Mechanical
Mixer Type	-	Turbine
Minimum unit power input for mixing	W/m3	300
Alum Storage Days	Days	30
Purity of alum	%	90
Concentration of alum solution for dosing	%	10
No of Dosing Pumps - Working	Nos	1
No of Dosing Pumps - Standby	Nos	1
Factor of Safety on Alum Dosing Pump	-	1.25
Type of Alum Dosing Pump	-	Hydraulic double diaphragm
Capacity of Monorail, Chain pulley block with Travelling Trolley (1 No)	MT	1.5
CHEMICAL BUILDING (FOR ALUM DOSING SYSTEM) FOR ALL TREATMENT PROCESSES		
Number of Building	Nos	1
MOC of Structure	-	RCC Framed Structure - M30
Minimum area of chemical building	m2	120
Height (from FFL to bottom of roof beam)	m	5
SCUM PIT		
MOC of Structure		RCC – M30
Number of sumps	Nos	1
Minimum operating volume of the sump	m3	15
SWD of Sump (Maximum)	m	1.8
Free Board (from Maximum water Level to top of the sump)	m	1.5
Scum Transfer Pumps		

Item/ Parameter/ Description	Units	WwTP at Channasandra
Minimum capacity of each pump	m3/h	10
Number of pumps - working	Nos	1
Number of pumps - standby	Nos	1
Type of Pump		Submersible chopper with recirculation valve
Capacity of Monorail, Chain pulley block with Travelling Trolley (1 No)	MT	1.5
DISC FILTER		
MOC Structure (Tank)		RCC – M30
Type	-	Disc Type
Flow Type	-	In-to-Out or Out-to-in
No of Units - Working	Nos	1
No of Units - Standby	Nos	0
Design flow per unit	-	Designed for 100% Peak Flows including recycle flows - Irrespective process
Inlet TSS	mg/L	20
Design load factor for Inlet TSS to Disc Filters	-	1.5
Outlet TSS from Disc Filter	mg/L	10
Maximum Opening size for disc	µm	10
Maximum Overflow Rate (At Peak Flow Rate)	m3/m2/h	10
Free Board	m	0.5
Minimum clear distance from disc filter to disc filter side wall (on all four sides)	m	0.6
Minimum clear operating spacing between two disc filters	m	1.2
Disc Filters Bypass Channel		
No of Units - Working	Nos	1
Design flow per unit	-	Designed for 100% Peak Flows including recycle flows - Irrespective process
Width to SWD ratio of bypass channel (Width/SWD)	-	1.5 to 2
Free Board	m	0.5
Disc Filter Effluent Channel		
No of Units	Nos	1
Design flow per unit	-	Designed for 100% Peak Flows including recycle flows - Irrespective process
Width to SWD ratio of bypass channel (Width/SWD)	-	1.5 to 2
Free Board	m	0.5
DISC FILTER BUILDING		
Location	-	Above Disc Filter
Number of Building	Nos	1
MOC of Structure	-	Framed Steel Structure with Mangalore roof tiles
Area of disc filter building	m2	Shall be covered complete disc filters including its inlet, outlet and bypass channels

Item/ Parameter/ Description	Units	WwTP at Channasandra
Height (from FFL to bottom of roof beam)	m	5
CHLORINE CONTACT TANK		
MOC of Structure		RCC – M30
Inlet flow distribution		Through flow distribution box equipped with weir plate for equal flow distribution to each CCT. Each weir shall be followed by isolation gate to each CCT.
Outlet flow		Through overflow weir.
Tank Geometry for CCT		Rectangular tank with inlet and outlet channels. Inside configuration of tank shall be such that it shall create the three pass flow to meet the design condition. Also, all inside corners of tank shall be filleted.
Type of Tank Design for CCT		Serpentine Design with Long Channels
CCT Flow Distribution Box		
Type	-	Rectangular
Number of units	Nos	1
Design flow per unit	-	Designed for 100% Peak Flows including recycle flows - Irrespective process
HRT at peak flow	s	45
Free board	m	0.5
CCT		
Maximum Design flow to unit	m3/h	Designed for 100% Peak Flows including recycle flows - Irrespective process
No of Units - Working	Nos	2
Minimum HRT for CCT (At peak flow condition)	Minutes	15
Effective L/W ratio	-	40
SWD/Pass Width ratio	-	1
Thickness of baffle wall	m	0.25
No of Passes	Nos	3
Fillet Radius for Serpentine Design of CCT	m	Same as Pass width
Free Board	m	0.5
CCT Effluent Channel		
No of Units	Nos	1
Design flow per unit	-	Designed for 100% Peak Flows including recycle flows - Irrespective process
Width to SWD ratio of bypass channel (Width/SWD)	-	1.5 to 2
Free Board	m	0.5
OUTFALL STRUCTURE		
MOC of Structure		RCC – M30
Design flow per unit	-	Designed for 100% Peak Flows including connecting pipe from outlet of CCT - Irrespective process
No of Units	Nos	1
Height of Structure above FGL at disposal Point	m	1
Overflow to Drain	Type	Free Flow / Through Overflow weir

Item/ Parameter/ Description	Units	WwTP at Channasandra
DISINFECTION SYSTEM		
Type of Disinfection System	-	Chlorine Gas
Design flow per unit	-	Designed for 100% Peak Flows including recycle flows - Irrespective process
Minimum Dose rate	mg/L	5
Type of Chlorinator	Type	Vacuum type-Gas Feed
Type of Chlorine Ejector	Type	Inline vacuum induction
Type of Booster Pumps	Type	horizontal centrifugal
No of working Chlorinator including Ejector and Booster Pumps (For Discharge)	Nos	1
No of working Chlorinator including Ejector and Booster Pumps (For Reuse)	Nos	1
No of standby Chlorinator including Ejector and Booster Pumps	Nos	1
Capacity of Chlorinator with Ejector	kg/h	5
Diluted chlorine concentration from booster pumps	%	0.1
Maximum chlorine withdraw rate per tonner	kg/h	4.5
Chlorine storage	Days	15
Chlorine Ton Cylinders Steel (SA516 Gr 60)	Nos	4
Chlorine Cylinder Load Cell (Electronic type)	Nos	1
Capacity of Motorized Monorail Hoist (1 No)	MT	3
RCC type Chlorine Neutralization Pit	Size	L-3.0m, W-1.8m, H-2.5m
Emergency chlorine scrubber of type Caustic wet chemical scrubber - Automatic		Emergency chlorine scrubber with all required pumps (1W+1S), required blowers (1W+1S) and all other required accessories and safety equipment's complete.
Capacity of GRP type Caustic Storage Tank	m3	1.5
CHLORINATION BUILDING		
Number of Building	Nos	1
MOC of Structure	-	RCC Framed Structure - M30
Length	m	12
Width	m	8
Height (from FFL to bottom of roof beam)	m	5
REUSE FACILITIES		
Reuse Flow	MLD	10
Operating Hours for Reuse Facilities	Hrs	20
Hourly Operating Flow for Reuse Facilities	m3/h	500
Membrane tank / Feed sump Capacity	m3	As per Design
No of Feed Pump/Permeate Pump (Working)	Nos	4
No of Feed Pump/Permeate Pump (Standby)	Nos	1
Capacity of each Feed Pump/Permeate Pump	m3/h	125
Type of Feed Pump/Permeate Pump	-	As per Design
No of Membrane Trains	Nos	5
Capacity of each Membrane Train	m3/h	125

Item/ Parameter/ Description	Units	WwTP at Channasandra
Minimum UF Plant Recovery	%	95
Maximum Membrane Flux Rate	LMH (liters/m²/hour)	30
Membrane Pore Size		0.01 – 0.03 µm to remove suspended solids, bacteria, and viruses
Membrane Type		Submerged (out-to-in) or Pressurized (outside-in or inside-out) hollow fiber membranes, designed to handle peak plant flow conditions.
Membrane Material (MOC)		Poly-Vinyli-Dene-Fluoride (PVDF) reinforced with polyester or polypropylene backing layer.
Temperature Tolerance		Membranes operational between 5–45°C
pH Tolerance		Operational range 6.5–8.5, with cleaning protocols adjusted for deviations.
Operating Pressure		As per Design
Feed Water to Membrane		Outlet of disc filters / Outlet of CCT
UF Membrane design load factor (on BOD and TSS)	-	2
Backwash Mechanism		Submerged UF: Air scouring combined with back flushing (permeate water). Pressurized UF: Reverse permeate flow and air-assisted backwash. or as per vendor recommendations.
Backwash Frequency		Every 10–60 minutes, depending on fouling rate and trans-membrane pressure (TMP) increase. or as per vendor recommendations.
Chemical Enhanced Backwash (CEB)		Every 24–48 hours using low-concentration oxidants, acids, or alkaline solutions to control bio-fouling and scaling. or as per vendor recommendations.
Membrane Cleaning (CIP)		Offline Cleaning-in-Place (CIP) every 3–6 months using alkaline and acid cleaning agents to restore permeability. or as per vendor recommendations.
Offline maintenance cleaning		Annually or as per vendor recommendations.
MOC of UF Building (Submerged / Pressurized)	-	Framed Steel Structure with Mangalore roof tiles
Area of UF Building	m2	As per Design
Industrial Reuse Storage (GLR)		
MOC of Structure		RCC – M30
Reuse Flow	MLD	10
Number of sumps	-	1 No Closed rectangular GLR with two compartment having: 1) 1.0m clear free board 2) Air vent system 3) 4Nos 1200mm Diameter circular machine-hole with 600H x 200 Thick kerb wall on top. 4) Baffle walls in each compartment

Item/ Parameter/ Description	Units	WwTP at Channasandra
		5) 1200mm wide stair case access to each compartment
Minimum HRT of the GLR based on Reuse Flow	Hrs	2
SWD of Sump (Maximum)	m	4
Free Board (from Maximum water Level to bottom of roof)	m	1
Industrial Reuse Pumping Station		
Number of Building	Nos	1
MOC of Structure	-	RCC Framed Structure – M30
Area of Reuse Pumping Station	m2	100
Height (from FFL to bottom of roof beam)	m	5
Type of Pump	-	Horizontal centrifugal
No of Pumps (Working) - Future Installation	Nos	4
No of Pumps (Standby) - Future Installation	Nos	1
Capacity of Each Pump - Future Installation	m3/h	125
Capacity of Fully EOT (LT,CT,Lift) (3 drives) Crane for Industrial Reuse Pumping Station (1 No)	MT	3
CENTRIFUGE SYSTEM		
Minimum Sludge Generation Fraction @ Inlet BOD load	kg/kg	0.82
Maximum Under flow sludge consistency	%	0.8
Centrifuge Feed Sump		
MOC of Structure		RCC – M30
Number of Sumps	Nos	1
Side water depth (Maximum)	m	3.5
Minimum HRT of the sump	Hrs	Non-operating hours of the centrifuge
Free Board (at Maximum sludge level)	-	1
Top of sump	-	Shall be covered with RCC slab with access machine-hole and staircase
Type of mixing for Centrifuge Feed Sump	-	Mechanical
Mixer Type	-	Submersible
Required unit power input for mixing	W/m3	15
No of Mixers	Nos	2
Type of Centrifuge Feed Pump	type	Progressing Cavity with VFD Control
Centrifuge Feed Pumps-Working	Nos	2
Centrifuge Feed Pumps-Standby	Nos	1
Operating hours for Centrifuge Feed Pump	Hrs	16
Capacity of Fully EOT (LT,CT,Lift) (3 drives) Crane for Centrifuge feed pumps (1 No)	MT	3
Centrifuge		
Operating hours for centrifuge	Hrs	16
Outlet sludge consistency from centrifuge	%	20
Maximum VSS/TSS Ratio	%	70
Minimum solid capture from centrifuge	%	95
Type of Centrifuge	-	Solid Bowl Decanter Centrifuge with main

Item/ Parameter/ Description	Units	WwTP at Channasandra
		and back drive mechanism. Both Drives shall be controlled with dedicated VFDs
Centrifuge - Working	Nos	2
Centrifuge - Standby	Nos	1
Capacity of Centrifuge	-	Same as capacity of centrifuge feed pump
Type of Sludge Hopper from each Centrifuge	-	Pneumatic / Hydraulic Operated Cut Gate
Type of sludge conveyor (1 No)	-	Shaft Type Helical Screw
Diameter of sludge screw conveyor	mm	450
Capacity of Motorized Monorail Hoist (Centrifuge Building)	MT	3
Dewatered Sludge Containers (5m3 each)	Nos	2
Poly Dosing System		
Minimum poly dosing rate	kg/T	5
Type of polymer system	-	Auto Polymer System with Tank, Polymer feeder, Mixers, dosing pumps etc.,
Concentration of solution from polymer system	%	0.1
MOC of Dosing Tank	-	GRP or HDPE
Total No of Dosing Tanks	Nos	3
Volume provided	m3	Each tank shall be sized to hold 2Hrs of Poly Solution based on design dosing rate and concentration
Free board	m	0.5
Type of mixing for polymer	-	Mechanical
Mixer Type	-	Turbine
Minimum unit power input for mixing	W/m3	200
Bulk Poly Storage	Days	30
Purity of Poly for Bulk Storage	%	99
Poly Storage Form	-	White Granules
No of Dosing Pumps - Working	Nos	2
No of Dosing Pumps - Standby	Nos	1
Factor of Safety on Poly Dosing Pump	-	1.25
Type of Poly Dosing Pump	-	Hydraulic double diaphragm
CENTRIFUGE FEED PUMP HOUSE		
Number of Building	Nos	1
MOC of Structure	-	RCC Framed Structure - M30
Length	m	10
Width	m	8
Height (from FFL to bottom of roof beam)	m	5
CENTRIFUGE BUILDING		
Number of Building	Nos	1
Number of Floors	Nos	G+1
MOC of Structure	-	RCC Framed Structure - M30
Length	m	12
Width	m	8

Item/ Parameter/ Description	Units	WwTP at Channasandra
Height of ground floor including mezzanine floor for sludge conveyor (from FFL to bottom of roof beam)	m	6.5
Height of first floor (from FFL to bottom of roof beam)	m	5
PLANT DRAIN SUMP		
MOC of Structure		RCC – M30
Number of sumps	Nos	1
Minimum operating volume of the sump	m3	30
SWD of Sump (Maximum)	m	1.8
Free Board (from Maximum water Level to top of the sump)	m	2
Minimum capacity of plant drain transfer pump	m3/h	25
Number of pumps - working	Nos	1
Number of pumps - standby	Nos	1
Type of Pump		Submersible pump
Capacity of Monorail, Chain pulley block with Travelling Trolley (1 No)	MT	1.5
TREATED WATER STORAGE SUMP (INTERNAL USE WITHIN WwTP)		
MOC of Structure		RCC – M30
Number of sumps	Nos	1
Minimum operating volume of the sump	m3	70
SWD of Sump (Maximum)	m	3
Free Board (from Maximum water Level to top of the sump)	m	1
Minimum capacity of plant water pumps (For Plant Internal use)	m3/h	25
Number of plant water pumps - working	Nos	1
Number of plant water pumps - standby	Nos	1
Type of plant water pumps		Submersible pump
Capacity of Monorail, Chain pulley block with Travelling Trolley (1 No)	MT	1.5
TREATED WATER TRANSFER PUMPS (FOR TANKER FILLING)		
Number of pumps - working	Nos	1
Number of pumps - standby	Nos	1
Minimum Capacity of each pump	m3/h	50
Type of plant water pumps	-	Horizontal centrifugal
Location of Treated Water Transfer Pumps	-	Reuse Pumping Station
TRANSFORMER YARD		
Area	m2	48
ELECTRICAL SUB-STATION BUILDING		
MOC of Structure	-	RCC Framed Structure - M30
Area	m2	150
Height (from FFL to bottom of roof beam)	m	5

Item/ Parameter/ Description	Units	WwTP at Channasandra
PLANT DG BUILDING		
MOC of Structure	-	RCC Framed Structure - M30
Area	m2	120
Height (from FFL to bottom of roof beam)	m	5
ADMIN BUILDING INCLUDES PLC SCADA, LABORATORY		
Number of Floors	Nos	G+2
MOC of Structure	-	RCC Framed Structure - M30
Area of each floor	m2	120
Height (from FFL to bottom of roof beam)	m	4.5
Elevator		Three side glass capsule elevator having capacity to carry minimum Eight (8) People at a time
PARKING AREA		
MOC of Structure	-	Stilt Floor of Admin Building
Area	m2	Refer Admin Building Area
Height (from FFL to bottom of roof beam)	m	4.5
GUARD ROOM (SECURITY ROOM)		
MOC of Structure	-	RCC Framed Structure - M30
Area	m2	10
Height (from FFL to bottom of roof beam)	m	3

15.20.2 Format for Process and Civil Unit for WwTP and TSPS

Process and Civil Unit List							
S.No	**Name**	**Nos**	**Length (m)**	**Width / Breadth (m)**	**SWD / Height (m)**	**Diameter (m)**	**Free Board (m)**

15.20.3 Format for Mechanical Equipment List for WwTP and TSPS

S.No	Equipment	Type	Unit Process / Location	Minimum Number of Units				Minimum Installed Capacity per Unit		Electrical Drive Type (CS/VFD)	Service (C/I)
				Working	Standby	Store	Total	Capacity	UOM		

S.No	Equipment	Type	Unit Process / Location	Minimum Number of Units				Minimum Installed Capacity per Unit		Electrical Drive Type (CS/VFD)	Service (C/I)
				Working	Standby	Store	Total	Capacity	UOM		
Legend: CS = Constant Speed; VFD = Variable Frequency Drive; C= Continuous; I = Intermittent; UOM = Unit of Measurement											

End of Part 5

PART 6

GENERAL ELECTRICAL REQUIREMENTS

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List of Abbreviations

AC	Alternating Current
AMF	Automatic Mains Failure
APFC	Automatic Power Factor Correction Panel
BEE	Bureau of Energy Efficiency
BIS / IS	Bureau of Indian Standards / Indian Standards
BoQ/BoM	Bill of Quantity / Bill of Material
CPCB	Central Pollution Control Board
CRCA	Cold Rolled Close Annealed
CT	Current Transformer
DC	Direct Current
DG	Diesel Generator
ETAP	Electrical Transient Analyzer Program
GA	General Arrangement
HV / HT	High Voltage / High Tension
ICOG	Incoming and Outgoing
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
KSPCB	Karnataka State Pollution Control Board
LED	Light Emitting Diode
LV / LT	Low Voltage / Low Tension
MCB	Miniature Circuit Breaker
MCC	Motor Control Centre
MCCB	Moulded Case Circuit Breaker
NBC 2016	National Building Code, 2016
NEC 2023	National Electrical Code of India 2023
OEM	Original Equipment Manufacturer
OLTC	On Line Tap Changer
ONAN	Oil Natural Air Natural
OSR	Oil Surge Relay
OTI	Oil Temperature Indicator
PCC	Power Control Centre
PLC	Programmable Logic Controller
PRD	Pressure Relief Device
PT	Potential Transformer
PVC	Poly Vinyl Chloride
QAP	Quality Assurance Program
RCCB/RCD	Residual Current Circuit Breaker / Residual Current Device
RMU	Ring Main Unit
SLD	Single Line Diagram
UPS	Uninterruptible Power Supply
VCB	Vacuum Circuit Breaker
WTI	Winding Temperature Indicator
XLPE	Cross Linked Polyethylene

PART 6

GENERAL ELECTRICAL REQUIREMENTS

6.1 Introduction

The general requirements include design, manufacture, inspection, and testing at works, supply and delivery at the site, unloading and storing the equipment at the site of installation, and testing and commissioning of the equipment at the site listed below. All the electrical and instrumentation equipment to be supplied under this contract have to be of reputed makes. The equipment of those manufacturers, who have sufficient proven experience of manufacturing the respective equipment of similar capacity, shall be considered. The respective equipment should have been manufactured, supplied, installed, commissioned successfully and should be running satisfactorily since at least for the last 5 years continuously. Certificates from the end users, regarding their satisfactory performance, shall have to be submitted in this regard. All equipment shall be OEM (Original Equipment manufacturer) type only.

Particular requirements of all electrical equipment are covered under 'Part 12: Particular Requirements – Electrical' of this Specification. All the equipment / items shall conform to latest applicable standards specified. In case of conflict between standards and this specification, this specification shall govern.

6.2 Equipment

(a) Transformers
(b) MV Metal enclosed switchboards & switchgears
(c) 415V Metal enclosed switchgears PCC / MCC / DG PCC Panel
(d) Power capacitor and control panel (APFC)
(e) Soft Starters
(f) Diesel Standby Generator with AMF Control Panel and Synchronizing panel
(g) Battery, Battery Charger and DC Distribution Board
(h) Variable Frequency Drives & Active Harmonic Filter Panels
(i) Non-Segregated Bus Duct
(j) Power & Control cables
(k) Cable Carrier system
(l) Lighting system
(m) Earthing and Lightning protection systems
(n) Solar PV System

Equipment manufacturer shall manufacture & test the equipment as per the below specifications and submit the QAP along with data sheet, technical particulars, GA drawing, BoQ etc. QAP shall list and define in sequential order all process control activities, inspection, and tests proposed to be performed on the equipment/ material, starting from component procurement and from testing stages to product dispatch. The QAP shall indicate and identify the applicable standards, place of inspection, detailed description with diagram the procedure, acceptance criteria, extent of check and record to be generated.

The equipment manufacturer shall ensure that equipment manufactured is strictly as per the Code 'A' / Final approved document only and then inform the readiness of the equipment for factory inspection by employer/employer's representative. Manufacturer shall provide plan of inspection based on the availability of the test bed in their factory and number of days required to complete the full factory inspection as per the approved QAP. Delay in conducting the inspection after reaching the factory premises due to non-readiness of equipment, non-availability of any items, test bed, inspection staff etc. will not be entertained.

6.3 Transformers

The transformer system shall have provision for interoperability with the instrumentation control system.

6.3.1 Applicable Standards

The design, manufacture, testing and performance of equipment shall comply with all currently applicable standards, codes of practice, regulations and safety codes in the locality where the equipment will be supplied. Nothing in this specification shall be construed to relieve the VENDOR/BIDDER of its responsibility. In case of conflict between these standards and this specification, the more stringent of the two requirements shall govern.

The codes and standards mentioned in the various specifications and requirements specified in the bid document shall be the latest as on the day of award of contract of the works unless otherwise specified. The contractor is responsible for informing the Consultant/ Employer in case of any revisions/re-affirm/amendments in the relevant codes and standards after the date of award of the contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. The Consultant/Employer may approve the use of the earlier code/standard if the revisions do not materially affect the statutory requirements of the project or impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed

Some of the currently applicable standards are indicated below

Power Transformer	IS: 2026/ IEC: 60076
Fittings and Accessories	IS: 3639
Outdoor type oil-immersed distribution transformers up to 2500kVA, 33kV Transformer Procedure for testing	IS: 1180 Latest Amend. 4 IS: 1180 / IS: 2026
Loading Guide of Oil Immersed Transformer Loading Guide for Dry-type Power Transformers	IS:2026 -7, IEC:60076-7 IS:2026-12, IEC:60076-12
Transformer Oil	IS:335/BS 148/IEC:60296
Bushings	IS/IEC:60137, IEC 60137
Degree of Protection	IS/IEC 60529, IEC 60529
Double float type Buchholz Relay	IS:3637
Electrical insulation classified by thermal stability	IS 1271/BS:2757/IEC:60085
Code of Practice for selection, installation, and Maintenance of transformers	IS:10028
Manual on Transformers	CBIP Publication No.317

6.3.2 Features of Construction

The transformer tank shall be made from high-grade sheet steel, suitably reinforced by stiffeners made of structural steel sections. All seams, flanges, lifting lugs, braces, and other parts attached to the tank shall be welded. The interior of the tank shall be cleaned by sand blasting and painted with two coats of heat-resistant, oil-insoluble paint. Adequately sized manholes shall be provided for ease of inspection

and maintenance. Steel bolts and nuts exposed to the atmosphere shall be galvanized. The tank cover shall be removable and suitably sloped to prevent accumulation of rainwater.

Lifting lugs and eyebolts shall be positioned to ensure a safe clearance is maintained without the use of a spreader between the sling and transformer bushings.

Transformers shall be provided with fixed-type radiators. Fins of the radiators shall not have sharp edges and shall be rounded in shape.

The transformer core shall be constructed from high-grade, non-ageing, cold-rolled, grain-oriented, silicon steel laminations. The steel laminations shall be of "core" type. Each lamination shall be coated with insulation which shall be unaffected by the temperature attained by the transformer during service. Core laminations shall be annealed, and burrs removed after cutting. Cut edges shall be insulated. The framework and clamping arrangements of core and coil shall be securely earthed inside the tank by a copper strap connection to the tank.

Windings shall be of electrolytic Copper of 99.99% purity.

Windings and insulation shall be arranged so that free circulation of oil is possible between coils, between windings, and between windings and the core. The windings shall be fully shrunk under vacuum before assembly. High voltage end-windings shall be suitably braced to withstand short circuit stresses and stresses caused up by surges.

The sequence and orientation of HV / LV side phase and neutral bushings shall be as specified in the latest edition of the relevant IS.

The transformer shall operate without injurious heating at the rated kVA and at any voltage up to + 10% of the rated voltage of any tap. The transformer shall be designed to withstand 110% continuous over-fluxing.

The transformer shall be provided with zero sequence/earth fault current protection on the LV side transformer feeder protection. (Neutral CT to be provided in case of solid grounding)

6.3.3 Winding Connections

Windings shall be of HV: Delta & LV: Star, vector group Dyn11.

6.3.4 Rating

The rating of transformers shall be as per standard ratings shown in IS 1180 / CBIP Publication 317. The energy efficiency level (EEL) of the transformer shall comply with the latest amendment of IS 1180 with a minimum EEL of Level II. The maximum single transformer rating shall be restricted to 2,500 kVA.

6.3.5 Type of cooling

The transformers shall be oil-immersed with natural oil circulation, type ONAN.

6.3.6 Impedance and losses

The percentage impedance, no-load, and load losses shall be as per the latest amendment of IS 1180/IS 2026 for Energy Efficiency Level II.

6.3.7 Oil

Transformers shall be supplied complete with transformer oil and shall be free of Polychlorinated biphenyls (PCB) and polycyclic aromatic hydrocarbons-free mineral oil or Synthetic ester oil.

6.3.8 Performance requirements

(a) The transformers shall be suitable for operation without danger to any particular tapping at the rated kVA, provided that the voltage does not vary by more than ± 10% of the voltage corresponding to the tapping.

(b) The transformers shall be suitable for continuous operation with a frequency variation of ±5 % of the rated frequency. The combined voltage and frequency variation should not exceed 10%.

(c) All transformers shall be capable of withstanding an external short circuit without damage as per IS 2026.

(d) The transformers shall be capable of continuous operation in accordance with the relevant Indian Standard (IS) for the loading of oil-immersed transformers.

(e) The neutral terminal of star windings shall be designed for the highest overcurrent that can flow through this terminal.

(f) The temperature rise of oil & windings over the specified ambient temperature shall not exceed the limits given below with air as the cooling medium when tested in accordance with IS 2026 (Part-2).

Top oil (measured by thermometer)	:	35° C
Winding (measured by resistance)	:	40° C

(g) Noise level of transformers measured at a distance of 1 metre shall be as per the limits specified in NEMA standard/IS 2026-10.

6.3.9 Tap Changer

For transformers with a rating of 500 kVA or less, tap changing shall be carried out using an off-circuit, externally operated, self-positioning switch when the transformer is in a de-energized condition. Tapings shall be provided on the higher voltage winding for variations of HV voltage from +5 % to-10% in increments of 2.5%. For a transformer of rating greater than 500kVA, a load tap changer shall be provided on the HV side for variation of HV voltage from plus 5% to minus 15% in steps of 2.5% with Remote Tap Changing Controller (RTCC), Automatic Voltage Regulator (AVR), etc.

On Load Tap Changing Gear for Transformer (above 500kVA)

(a) The OLTC gear shall be designed to complete tap changes successfully for the maximum current to which the transformer can be loaded, i.e., 150% of the rated current. Devices shall be incorporated to prevent tap change when the through current exceeds the safe current that the tap changer can handle. The OLTC gear shall withstand fault currents without injury.

(b) When a tap change has been commenced, it shall be completed independently of the operation of the control relays and switches. Necessary safeguard shall be provided to allow for failure of auxiliary power supply or any other contingency which may result in the tap changer movement not being completed once it shall be commenced.

(c) Oil in compartments that contain the making and breaking contacts of the OLTC shall not mix with oil in other compartments of the OLTC or with transformer oil. A pipe shall convey gases released from these compartments to a separate oil conservator or to a segregated compartment within the main transformer conservator. A Buchholz relay shall be installed in the above pipe. The segregated compartment (conservator) shall be provided with a prismatic oil level gauge.

(d) Oil, in compartments of the OLTC that do not contain the make and break contacts, shall be maintained under a conservator head by valve pipe connections. Any gas leaving these compartments shall pass through the Buchholz relay before entering the conservator.

(e) Oil-filled compartments shall be provided with a filling plug, a drain valve with a plug, an air release vent, an oil sampling device, an inspection opening with a gasketed and bolted cover with a lifting handle.

(f) OLTC driving mechanism and its associated control equipment (Local) shall be mounted in an outdoor, weather-proof cabinet with IP65 protection, which shall include:

(i) Driving motor (415V, 3-phase, 50 Hz. AC squirrel cage).
(ii) Motor starting contactor with thermal overload relays, isolating switch, and MCB.
(iii) Duplicate sources of power supply with automatic changeover from the running source to the standby source and vice versa.
(iv) Control switch: Raise / Off / Lower (spring return to normal type).
(v) Remote / Off / Local selector switch (maintained contact type).
(vi) Mechanical tap position indicator displaying the rated tap voltage at each position, along with resettable maximum and minimum indicators.
(vii) Limit switches to prevent motor over-travel in either direction or final mechanical stops.
(viii) Brake or clutches to permit only one tap change at a time on manual operation.
(ix) Emergency manual operating device (hand crank or hand wheel).
(x) A five-digit operation counter.
(xi) Electrically interlocked reversing contactors (preferably also mechanically interlocked).
(xii) 240V, 50 Hz. AC space heater with thermostat and MCB.
(xiii) Interior lighting fixture with lamp door switch and MCB.
(xiv) Gasketed and hinged door with locking arrangement.
(xv) Terminal blocks, internal wiring, earthing terminals and cable glands for power and control cables.
(xvi) Necessary digital protection relays, contactors, current transformers etc.

(g) Control Requirements for OLTC

The following electrical control features shall be provided:

(i) Positive completion of load current transfer, once a tap change has been initiated, without stopping on any intermediate position, even in case of failure of the external power supply.
(ii) Only one tap change is allowed from each tap change impulse, even if the control switch or push button is maintained in the operated position.
(iii) Cut-off of electrical control when manual control shall be resorted to. Cut off the counter impulse for a reverse tap change until the mechanism comes to rest and resets the circuits for a fresh operation.
(iv) Cut-off of electrical control when it tends to operate the tap beyond its extreme position.

(h) Automatic Control of OLTC

Automatic OLTC control shall include the following items:

(i) Voltage setting device
(ii) Voltage sensing and voltage regulating devices.
(iii) Line drop compensator with adjustable R and X elements.
(iv) Timer 5-25 seconds for delaying the operation of the tap changer in the first step for every tap change operation.
(v) Adjustable dead band for voltage variation

(h) OLTC Panel:

The OLTC remote control equipment shall be suitable for a 110V DC supply and shall be housed in an indoor, sheet-steel cubicle located in a remote-control room. The OLTC control panel shall comprise rigid welded structural frames made of structural steel sections or of pressed and formed cold-rolled steel, and frame enclosures, doors, and partitions shall be of cold-rolled steel of thickness 2mm. Stiffeners shall be provided wherever necessary. All doors, removable covers and plate shall be gasketed all around with neoprene gaskets. The panel shall be dust, weather, and vermin proof, providing a degree of protection equivalent to IP54. The colour of finish shade for interior and exterior shall be glassy white and light grey semi-glossy shade 631 of IS-5, respectively. The earthing bus shall be of 25 x 6 mm copper.

The OLTC remote control equipment shall comprise the following:

(i) Control switch : Raise / Off / Lower (Spring return to normal type)
(ii) Auto / Off / Manual selector switch (Maintained contact type).
(iii) Tap position indicator.
(iv) Fascia type alarm annunciations with "accept" and "lamp test" facilities.
- A.C. supply failure.
- Drive motor auto tripped.
- Tap change delayed.

(v) Necessary auxiliary relays.
(vi) Lamp indications for:
- Tap change in progress.
- Lower limit reached.
- Upper limit reached.

(vii) Double compression Cable glands for power and control cables.
(viii) 240 V rated panel space heater with thermostat and ON-OFF MCB.
(ix) LED type energy efficient (lumen per Watt shall be specified) interior lighting fixture with lamp and door switch.
(x) MCB / HRC fuses.
(xi) Terminal blocks.
(xii) Internal wiring.
(xiii) Earthing terminal.

Off Load Tap Changing Mechanism for Transformer (Less than or equal to 500kVA)

Off circuit tap changing mechanism shall comprise the following:

i) Operating handle of wheel, accessible from ground level.
ii) Tap position indicator.
iii) Pad locking arrangement.
iv) The tap-changer connections and contacts shall be accessible through an access hole having a bolted gasketed cover.

6.3.10 Marshalling Box

The marshalling box shall be provided to marshal temperature indicators with auxiliary contacts, Buchholz relay, and bushing CT shall be marshalled to the contacts/terminals of electrical devices mounted on the transformer

i) The interconnection cabling between the marshalling box and the accessory devices by either PVC insulated FR wires in GI conduits or PVC insulated inner extruded PVC, Outer sheath PVC FR armoured cable, and

ii) Necessary compression type, brass cable glands (at easily accessible location) at the marshalling box for the above-mentioned cables.

The marshalling box shall be tank-mounted, outdoor type, IP55 protected, weatherproof, and enclosed in sheet steel (2 mm thick), with a hinged door featuring a padlock facility. The colour finish shall be epoxy paint, powder-coated with a minimum thickness of 50 microns and a dark grey shade (RAL 632). All doors, covers, and plates shall be fitted with neoprene gaskets. The bottom shall be at least 600 mm from floor level and shall be provided with a gland plate and cable glands as required. The top surface shall be sloped.

All contacts for alarm, trip, and indication circuits shall each be potential-free, wired for auxiliary D.C. supply as specified, and brought out to separate terminals at the terminal blocks in the marshalling box. Terminals shall be rated for 10A.

Wiring shall be FRLS/HFFR with multistranded, copper conductors of sizes not smaller than 1.5 sq.mm for control and 2.5 sq.mm for CT circuits. CT terminals shall be provided with shorting & earthing facility.

The marshalling box shall be provided with a glass window, allowing the WTI and OTI dials to be visible from the outside without opening the door.

The marshalling box shall house the winding temperature indicator (WTI, 150 mm dial 240-degree scale), the oil temperature indicator (OTI, 150 mm dial 240-degree scale), terminal block, 60W anti-condensation heater, 5/15A industrial type five pin socket and a LED fixture, suitable for operating on 230 V AC. Contacts of Buchholz relay, WTI, OTI, magnetic level gauge, PRD, OSR shall be wired up to the terminal block.

6.3.11 Fittings and Accessories

The following fittings and accessories shall be provided with the transformer:

(a) Name plate, rating plate and diagram plate as per IS 1180.

(b) Two earthing terminals on opposite ends of the transformer tank.

(c) A neutral earthing bar of copper, of the specified section, installed from the neutral bushing to ground level, suitably supported along its run by porcelain insulators, together with clamping arrangements at the neutral bushing and for the two Employer's earth conductors. The supporting insulators shall be tank mounted.

(d) Inspection manhole(s) with cover(s) on the top cover of the transformer.

(e) Lifting lugs or eyes for lifting the fully assembled transformer, core assembly, and tank core using a crane.

(f) Conservator, complete with filling plug, sump, and drain valve, and a shut-off valve on the pipe connection between the transformer tank and the conservator, to permit removal of the conservator. The conservator shall be designed to maintain an oil seal over a temperature range of 100 °C.

(g) Oil level gauge indicating oil level at minimum, 30 °C, and maximum operating temperature.

(h) Weather-proof dehydrating breather with a clear polycarbonate desiccant container. The weight of the desiccant shall meet a 400 charge life days. The desiccant type shall be self-indicating bread silica gel as the dehydrating agent.

(i) For all transformers, a magnetic-type oil level gauge with a low oil level alarm contact shall be mounted on the conservator, equipped with a waterproof and dustproof terminal box, and shall be wired to the marshalling box.

(j) Gas detector relays with separate alarm and trip contacts, complete with shut-off valves, shall be wired to the marshalling box.

(k) A Separate drain valve, an oil sampling valve with a plug, and a top filter valve shall be provided on the tank and shall be leak-proof after commissioning.

(l) Explosion vent with diaphragm for relieving pressure inside the transformer. The device shall be rainproof after operation. For transformers of 500 kVA and above, an equalizer pipe connecting the pressure relief device to the conservator shall be supplied.

(m) Buchholz relay, pressure relief device, and winding and oil temperature protection with alarm and trip contacts shall be provided on all transformers of ratings 1000 kVA and above.

(n) Separately mounted, waterproof and dustproof marshalling box housing the Buchholz relay wiring, oil level low wiring, oil temperature indicator and winding temperature indicator with alarm and trip contacts and marshalling facilities for electrical devices mounted on transformer including load management signal shall be provided to give an information about the over loading condition of the transformer and all signals shall be wire able to alarm annunciation. (The signal shall not give indication for momentary overloading). The marshalling box shall be in accordance with IS/IEC 60947. The degree of protection shall be IP65 with space heaters, etc.

(o) For transformers rated 500KVA and above. An adequate number of air vents shall be provided for relieving trapped air during oil filling and maintenance and shall be leak-proof after commissioning.

(p) Thermometer pockets and a sensing element are mounted on the transformer tank cover for measuring the top oil temperature.

(q) Four jacking pads for lifting the transformer with jacks.

(r) Pulling eyes and skids for the movement of the transformer.

(s) Bidirectional wheels for movement of the transformer.

(t) A ladder assembly shall be provided to access the top of the transformer for maintenance purposes. It shall be possible to padlock the ladder to the transformer tank so that the ladder cannot be removed. The usage of transformer structure / marshalling boxes, etc., as a means to climb the transformer is not acceptable.

(u) Accessories for clamping the wheel-mounted transformer to the foundation in order to withstand earthquake forces with a seismic acceleration of 0.2g.

(v) The transformer shall be supplied complete with the insulating oil required for the first filling, plus 10% excess oil, in non-returnable drums, accompanied by a gas analysis report.

6.3.12 Cable Terminations / Cabling Requirement

Cable termination boxes for transformers shall be suitable for dry termination of HV and LV cables. Non-magnetic gland plates shall be provided for the termination of cables. The maximum size of the cable and the number of cables that can be terminated shall be indicated.

It shall be possible to remove the cable boxes without dismantling the cable gland or draining the oil. Disconnecting links shall be provided to facilitate testing of the cable.

All transformers shall be provided with alarm annunciation on the breaker control panel.

6.3.13 Tolerance on Losses

The permissible tolerances on the guaranteed values of transformer losses shall be as per IS 2026. The values of load losses and No-load losses shall be within the values given in the latest edition of CBIP.

Losses at 50% load & 100% load shall be minimum Energy Efficiency Level (EEL) -2 as per the latest amendment of IS 1180.

Cost loading shall be done for capitalization of losses at the time of bid evaluation for all transformers as per the CBIP Manual on transformers.

6.3.14 Rejection

The Employer or the Employer’s Representative reserves the right to reject the transformer if it does not meet the specification requirements, subject to tolerances as per IS 2026. The impedance value difference and temperature rise values shall not exceed the guaranteed specified values. The rejected transformers shall be replaced with transformers that comply with the requirements of this specification at the Contractor’s cost.

If the commissioning of the project is likely to be delayed by the rejection of a transformer, the Employer’s Representative reserves the right to accept the rejected transformer until the replacement transformer is made available. Transporting the rejected and replacement transformers, as well as the installation and commissioning of both the transformers, shall be at the Contractor's cost.

6.3.15 Drawings and Data

All Drawings, data, technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates of typical transformer etc shall be submitted along with the bid / after award of contract as specified under “Bid / Contract Drawings”, Part 3, General Requirements, Volume - 2 of Bid Documents.

6.3.16 Quality Assurance Plan (QAP)

QAP shall list and define, in sequential order, all process control activities, inspections, and tests, including the heat run test proposed to be performed on the equipment/material, from component procurement through testing stages to product dispatch. The QAP shall indicate and identify the

applicable standards, place of inspection, detailed description with diagram, the procedure, acceptance criteria, extent of check, and record to be generated.

6.4 MV Metal Enclosed Switchboards & Switchgears

MV Metal enclosed Switchboards and Switchgear system shall have a provision for interoperability with the instrumentation control system.

The technical specifications and data sheets cover 11kV switchgear and associated equipment such as Vacuum circuit breaker, CTs, and PTs, etc. to be supplied with 11kV switchboards suitable for 11kV, 3-ph, 50 Hz AC earthed system with fault level as specified in data sheets. The equipment shall be suitable for continuous operation at the stipulated ambient conditions. The supplied equipment shall be used as part of the contract and must comply with government regulations. Test certificates necessary to support certification must be submitted before the equipment is supplied.

6.4.1 Applicable Standards

The switchgear and its components shall conform to the latest applicable standards specified below:

The design, manufacture, testing and performance of equipment shall comply with all currently applicable standards, codes of practice, regulations and safety codes in the locality where the equipment will be supplied. Nothing in this specification shall be construed to relieve the VENDOR/BIDDER of its responsibility. In case of conflict between these standards and this specification, the more stringent of the two requirements shall govern.

The codes and standards mentioned in the various specifications and requirements specified in the bid document shall be the latest as on the day of award of the contract for the works unless otherwise specified. The Contractor shall be responsible for informing the Consultant/Employer of any revisions, reaffirmations, or amendments to the relevant codes and standards after the date of contract award, within 30 days of the issue of such revisions, reaffirmations, or amendments to the code or standard. Consultant/ Employer may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or do not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed

Some of the currently applicable standards are indicated below

Switchgear General Requirements AC Circuit Breakers	IS/IEC:60947, BSEN:60947, IS/IEC:61439-1 IS/IEC 62271-100
Factory Built Assemblies of Switchgear and Control Gear For Voltages up to and including 1000V AC and 1500V DC	BSEN: 61439-1, IS/IEC 61439-1 IEC 62271-200
Current Transformers	IS: 16227 / BS: 7626 / IEC 61869-2
Voltage Transformers	IS: 16227 / BS: 7625 / IEC: 60869-3
Arrangement for Switchgear Busbars, Main Connections and Auxiliary wiring	IS: 5578, 11353, BS:159
Busbar Support insulators	IS: 2544 / BS: 3297 / IEC: 60 273
Degree of Protection	IS/IEC:60529, IEC: 60529

Measuring Relays and Protection Equipment	IS/IEC: 60255
Electrical Indicating Instruments	IS: 1248 / BS: 89 / IEC: 60051
High Voltage Fuses	IS: 9385 / BS: 2692 / IEC: 60282
AC Electricity Meters	IS: 722, 8530 / BS: 5685 / IEC: 60145, 60211
Specification for copper rods and bars for electrical purposes	IS: 613
Code of practice for phosphate coated iron and steel	IS: 6005 / BS: 3189
Alternating current Switches for voltages above 1000V	IS: 9920 / IEC: 60129, 60265
HRC Cartridge fuses Miniature Circuit Breakers	IS: 13703-2 / BS 1362 / IEC 60269 IS/IEC: 60898
Toggle switches	IS: 3452 / BS: 3676
Code of practice for selection, installation and maintenance of switchgear and control gear	IS: 10118
Air Break switches	IS/IEC 60947-3, BSEN 60947-3 / IEC: 60947-3
Classification of Hazardous areas having Flammable gases and vapors for Electrical Installation	IS 5572, IEC 60079-10
Electrical apparatus for explosive gas atmospheres-General Requirements Fault level calculation Testing Guide	IEC 60079 IS: 13234 / IS:2026 ANSI/IEEE C.37.20.7

6.4.2 Constructional Features

Switchgear design shall be of metal enclosed, single front, free-standing, floor mounted, and fully compartmental execution having separate sections for each circuit

(a) control, metering and relaying devices

(b) circuit breaker/ disconnecting switch

(c) busbars

(d) voltage transformers and

(e) power cable terminations & current transformers

Each Circuit shall have a separate vertical panel with distinct compartments for main bus bars, circuit breaker, cable termination and auxiliary devices. Steel sheets shall completely separate the adjacent panel compartments except in bus bar sheet compartments, where insulated barriers shall be provided to segregate adjacent panels. Compartments with doors for access to the operating mechanism shall be arranged so as not to expose high-voltage circuits. The switchgear cubicle shall be provided with a hinged door on the front, featuring a facility for locking the door handle. Stiffeners shall be provided wherever necessary to strengthen the door and side covers. The switchboard shall be dust and vermin-

proof and shall have a degree of protection against ingress of IP 4X. The relay and meter compartments shall have a degree of Protection not less than IP 52. All removable covers shall be gasketed all around with neoprene or superior gaskets.

Each 11kV circuit breaker shall be housed in an individual panel in a single-tier formation. A channel of 75 x 5 mm thick shall be provided at the bottom. Rated continuous current rating at ambient temperature as specified in IS/IEC 62271.

The panel width shall be a minimum of 700mm, allowing for cable termination at a height of 600mm from the gland plate for improved connectivity and ease of maintenance.

Switchgear panel shall have the following features

a) Relays with internal fault monitoring.

b) Relay/metering shall be communicable to SCADA/Energy Management software using an open network protocol.

c) Relays with event and fault recording facility.

d) Extendable on both sides.

e) Arc protection unit.

f) Busbar temperature monitoring using wireless sensors.

Instruments, relays, and control devices shall be flush-mounted on the hinged door of the metering compartment located in the front portion of the cubicle. The metering compartment shall be properly shielded to prevent maloperation of electronic equipment, such as numerical/static relays, due to electromagnetic fields. All transformers shall be provided with alarm annunciation on the breaker control panel.

The switchgear panel height shall normally be restricted to a maximum of 2,300 mm. Panels shall be fabricated with CRCA sheet steel thickness not less than 2.0mm and shall be folded and braced as necessary for a rigid support for all components. The doors and covers shall be constructed from CRCA sheet steel of a thickness not less than 1.6 mm. Joints of any kind in sheet steel shall be seam-welded, and all welding slag shall be ground off, and welding pits shall be wiped smooth with plumber's metal.

Separate removable gland plates shall be provided for power and control cables. The gland plate for the power cables shall be of non-magnetic material for single-core cables.

Each switchgear cubicle shall be fitted with a label on the front and rear of the cubicle. Each switchboard shall also be fitted with a label indicating the switchboard designation, rating, and duty. Each relay, instrument, switch, fuse, and other devices shall be provided with a separate label.

The fully draw-out modules shall have all the circuit components mounted on withdrawable type steel chassis. All power and control connections shall be of the draw-out type. It shall be possible to withdraw the chassis-mounted circuit components without having to disconnect any connections. All draw-out contacts shall be of silver-plated copper. The power and control circuits shall have self-aligning and self-isolating contacts, which shall be easily accessible for maintenance. Mechanical interlocks shall be provided on the draw-out cubicles to ensure safety and compliance with relevant standards.

In the case of circuit breaker compartments, suitable barriers shall be provided between the breaker and all control, protective, and indicating circuit equipment, including instrument transformers, to ensure

that no live parts are accessible. External cable connections shall be through separate cable compartments for power and control cables. Safety shutters shall be provided to cover the fixed high-voltage contacts on busbars when the circuit breaker carriage is moved to the 'test' and 'isolated' positions.

One metal sheet shall be provided between two adjacent vertical sections running to the full height of the switchboard, except for the horizontal busbar compartment. However, each shipping section shall have metal sheets at both ends. After isolating the power and control connections of a circuit, it shall be possible to carry out maintenance in a compartment safely, with the busbars and adjacent circuits energized.

All sheet steel work shall be phosphate-coated in accordance with the following procedure and the IS: 6005, "Code of Practice for Phosphate-Coated Iron and Steel". Oil, grease, dirt, and swarf shall be thoroughly removed by emulsion cleaning. Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water, and drying.

After phosphate coating, thorough rinsing shall be with clean water, followed by final rinsing with dilute dichromate solution and even drying.

The phosphate coating shall be followed by the application of two coats of ready mixed stoving type zinc chromate primer. The first coat may be "flash dried" while the second coat shall be stoved. After application of the two coats of primer finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied after completion of tests.

The final finished thickness of paint film on steel shall not be less than 80 microns and shall not be more than 120 microns. The finished painted surface of panels shall present an aesthetically pleasing appearance free from dents and uneven surfaces.

A small quantity of finishing paint shall be supplied for minor touching up required at site after the installation of the panels.

<u>Other Requirements for Kiosk/ICOG (Indoor and Outdoor)</u>

The kiosk should be provided with a rear entry cable compartment for cable termination for the incoming power cable and an adjoining cable box for the outgoing cable termination, wherever necessary along with the following minimum requirements

- Housing for circuit breaker carriage
- Mechanical interlock and safety gear, including arrangements
- Isolation plugs of circuit breaker rating
- Vacuum circuit breaker with 3 nos. of vacuum interrupters assembly, complete with epoxy insulators and self-aligning finger type isolating contacts.
- Truck having integral rack-in device for insertion and withdrawal of VCB, complete with necessary interlocks.
- Panel heater elements with thermostat control of adequate wattage to ensure no moisture condensation inside the panel.
- For outdoor kiosk shall be constructed with sheet steel of
    - 10 SWG for sloping MS Canopy and
    - 14 SWG for internal doors, metering panel and internal partitions
- The outdoor kiosk shall be provided with louvered ventilators and screening strips to prevent the ingress of rodents.

6.4.3 Circuit Breaker

Circuit breakers shall be vacuum type (VCB) with three separate single-pole interrupting units, operated through a common shaft by a sturdy operating mechanism. Surge Arrestors shall be provided for each motor/transformer feeder. Circuit Breakers shall be re-strike-free, stored-energy-operated, and trip-free types. The circuit breaker, along with its operating mechanism, shall be mounted on a wheeled carriage that moves on guides, designed to align correctly and allow for easy movement. Plugs and sockets for power circuits shall be silver-faced and shall be insulated with suitable insulating material shrouds. All corresponding components of circuit breaker cubicles of the same rating shall be interchangeable with one another. An anti-pumping relay and a trip coil suspension relay shall be provided.

All VCB trucks of the same rating shall be interchangeable. Closing coil shall be operable with control supply voltage variation in the range of 85-110% and tripping coil shall be operable in the range of 70-110%.

There shall be 'Service', 'Test' 'Fully withdrawn' positions for the breakers. In the 'Test' position, the circuit breaker shall be capable of being tested for operation without energizing the power circuits; i.e., the control circuits shall remain undisturbed while the power contacts remain disconnected. Separate limit switches, each having a minimum of 2 'NO' + 2 'NC' contacts, shall be provided for both 'Service' and 'Test' positions of the circuit breakers. All these services, test, fully withdrawn, spring charge, and also breaker ON / OFF shall be visible mechanically from outside the breaker panel when the front door is closed.

Electrical closing and tripping shall be performed by shunt trip and close coils, both in Local, Off, and Remote modes. A selector switch lockable in the "Local" position shall be provided on the cubicle door. 'Red' and 'Green' indicating lamps shall be provided on the cubicle door to indicate the closed and open positions of the breaker. Breaker "Service", "Test", and "Breaker Readiness" positions shall be indicated by separate indicator lamps on the cubicle door.

The connection of the control and interlocking circuits between the fixed portion of the cubicle and the breaker carriage shall preferably be made by means of a plug socket arrangement.

10% spare feeders with at least one for each type of highest rating shall be provided in each switchgear.

Surge arrestors shall be provided for all incomer and transformer feeders, which shall be metal oxide gapped or gapless, type generally in accordance with IS 15086/IEC 60099 and suitable for indoor only. The selected surge arrestor shall be suitable for a non-effectively earthed system, and its rating shall be such that the value of the steep-fronted switching overvoltage generated at the switchgear terminals is limited to the requirements of the switchgear.

6.4.4 Main Busbar

Busbars shall be fully insulated and extendible on both sides with flame-retardant, heat-shrinkable sleeves featuring removable shrouds to protect all joints. The busbar phases shall be clearly identified with suitable colour coding at both ends of each transport unit. The withstand temperature of sleeves shall be at least 5 degrees centigrade more than the maximum busbar temperature. The busbar temperatures shall be limited to the values indicated in the technical data sheet without forced cooling.

The busbars shall be supported on non-breakable, non-hygroscopic, insulated supports at regular intervals to withstand the stress of the specified fault level.

Busbars shall be supported on insulators capable of withstanding dynamic stresses due to short circuit

6.4.5 Operating Mechanism Control

- A motor spring-charging type mechanism shall operate circuit breakers. The mechanism shall be complete with motor, opening spring, closing spring and all accessories to make the mechanism a complete operating unit.
- The operating mechanism shall normally be operated from the breaker cubicle itself.
- The tripping spring shall be charged by the closing action, to enable quick tripping. Closing the circuit breaker shall automatically initiate the recharging of the springs, enabling the mechanism to be ready for the next closing stroke. Charging time for the springs shall not exceed 30 seconds. It shall be possible to charge the springs in an emergency manually. Transfer from motor to manual charging shall automatically disconnect the charging motor. All operating mechanisms shall be provided with "ON" - "OFF" mechanical indication. The charging mechanism shall be equipped with mechanical indicators to display the "charged" and "discharged" conditions of the spring. Failure of any spring, vibration or mechanical shock shall not cause tripping or closing of the circuit breaker.
- Only one closing operation of the circuit breaker shall result from each closing impulse (manual or electrical), even if the breaker trips. In contrast, the control device (manual or electrical) shall be held in the "closed" position.
- The circuit breaker mechanism shall make one complete closing operation once the push button (PB) or control switch has been operated. The first device in the control scheme has responded, even though the PB or control switch shall be released before the closing operation completes, subject to the condition that there is no counter-impulse for tripping.
- Means shall be provided to manually open and close the breakers slowly, when the operating power shall not be available, for maintenance and adjustments. A local manual trip device shall also be provided on the operating mechanism.
- Circuit breaker control shall be on 110V DC. Closing coils and other auxiliary devices shall operate satisfactorily at all voltages between 80 - 110% of the control voltage. Trip coils shall operate satisfactorily between 50 - 110% the rated control voltage.

6.4.6 Safety Interlocks and Features

- Withdrawal or engagement of a circuit breaker shall not be possible unless it shall be in the open position.
- All circuit breakers shall have a lockable local / off / remote selector switch, and it shall be possible to close the breaker from local in both TEST / SERVICE positions. Closing from remote shall be possible in either the SERVICE or TEST position. For opening breaker from local shall be possible only when local / off / remote selector switch shall be in local position. The opening breaker from the remote shall be either the breaker in service position or the selector switch being in a remote position.
- All Motors and Service Transformers feeder breakers shall have a lockable emergency push button (openable only with key) near the motor and service transformer, hard-wired to the circuit breaker panel emergency push button.
- Operation of a circuit breaker shall not be possible unless it shall be in service position, withdrawn to test position or fully drawn out. It shall not be possible to close the circuit breaker electrically in the service position without completing the auxiliary circuit between the fixed and moving portions.
- Circuit breaker cubicles shall be provided with safety shutters that are automatically operated by the movement of the circuit breaker carriage to cover the stationary isolated contacts when the breaker shall be withdrawn. Padlocking facilities shall be provided to ensure the shutters are positively locked in the closed position. It shall, however, be possible to open the shutters intentionally against spring pressure for testing purposes.

- The circuit breaker carriage shall be earthed before the breaker reaches the test position from the fully withdrawn position. In case of breakers with an automatic disconnecting type of auxiliary disconnects, the carriage shall be earthed before the auxiliary disconnects are made, and the carriage earthing shall break only after the auxiliary disconnects break.
- A caution nameplate, "Caution Live Terminals," shall be provided at all points where the terminals are likely to remain live, and isolation shall be possible only at the remote end, i.e., incomer to the switchboard. Suitable interlock shall be wired for the purpose.

- The switchboard shall have passed internal arc testing for 1 second at the rated switchgear fault current. Pressure relief flaps shall be provided at the top of the switchboard with a suitable exhaust arrangement to release hot, over-pressurized gases in the event of an internal fault. The internal arc time could be 0.5 sec or 0.1 sec at switchgear rated fault current, in case rapid fault clearance time is initiated by detectors sensitive to light, pressure, or heat, or by bus bar differential protection is provided.

6.4.7 Earthing

Copper earthing bus shall be provided and extended throughout the length of the switchboard. It shall be bolted to the framework of each unit and brazed to the earthing contact bar of each breaker. It shall be located at the bottom of the board. The earth bus shall have sufficient cross section to carry the momentary short circuit and short time fault current for at least 1 second or higher without exceeding maximum allowable temperature rise. The earth bus shall be properly supported to withstand stresses induced by the momentary short circuit current.

Suitable clamp type terminals at each end of the earth bus shall be provided to suit the size of the earthing conductors. Bolted joints, slices, tap, etc. to the earth bus shall be made with at least two bolts. Positive earthing of circuit breaker frame shall be maintained when it shall be in the connected position and in all other positions whilst the auxiliary circuits are not totally disconnected.

Hinged doors shall be earthed through flexible earthing braid of adequate cross section. All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus.

Positive connection of the frames of all the equipment mounted in the switchboard to the earth busbar shall be maintained through insulated conductors of size equal to the earth busbar or the load current carrying conductor, whichever is smaller.

All instrument and relay cases shall be connected to earth busbar by means of 1100V grade, green coloured, PVC insulated, stranded, tinned copper, 2.5sq. mm conductor looped through each of the earth terminals.

6.4.8 Circuit / Busbar Earthing Facility

It shall be possible to connect each circuit or set of 3 phase bus bars of the switchboard to earth through earthing switches. Earthing switches / earthing devices shall be mechanically interlocked with the associated breakers to prevent accidental earthing of live circuit or bus bars.

In case the earthing facility comprises earthing trucks to be inserted in place of circuit breakers, separate earthing trucks shall be supplied for each type/size of breaker. The earthing facilities proposed to be provided by the Bidder shall be detailed in the Bid and shall be subject to the Employer's approval. Auxiliary contacts (min. 2 NO + 2 NC) shall be provided on each earth switch / earthing device and shall be wired to the terminal block for interlocking purpose.

6.4.9 Annunciators

Annunciators shall be of fascia type with translucent plastic window for each alarm point. Annunciated fascia plates shall be engraved in block lettering with respective alarm inscriptions. The inscriptions shall be clearly readable and visible when the respective fascia LED light shall be lighted. Each annunciation window shall be equipped with two LED lights to provide redundancy in the event of LED light failure. Lamps shall be replaceable from the front. Lamps shall be of clustered LED type.

All fascia annunciated points shall be suitable to accept external contacts of either 'NO' or 'NC' self or hand reset type for initiating the annunciation sequence, and shall be suitable for accepting fleeting faults of duration as short as 15 milliseconds.

For static annunciator schemes, special precaution shall be taken by the contractor to ensure that spurious alarm conditions do not appear due to the influence of external magnetic fields on the annunciator wiring and switching disturbances from the neighbouring circuits within the panels / desks.

A "Lamp Test" push button shall be provided for each individual panel's group of annunciators to limit the sudden drain on the battery. Provision of testing facilities for flasher and audible electronics alarm circuits of annunciators is desirable. The Contractor shall give the details of the offered scheme.

Annunciator shall have the following features:

- Suitable for annunciating subsequent faults immediately after the sound cancel of the previous fault.
- During lamp test, if a fault occurs, the corresponding lamp circuit shall be automatically disconnected from the "lamp test" circuit and shall start flashing.
- Designed to prevent maloperation of the scheme or sequence when the push buttons are pressed incorrectly or in the wrong order.
- "Alarm Supply Failure" Alarm scheme similar to the normal annunciation sequence, but shall operate on a different DC supply or on an AC auxiliary supply.
- Alarm annunciates having provision to integrate all alarm/trip signals to PLC.
- Alarm annunciation shall be provided for transformers, the chlorination system, and the surge vessel system wherever discrete local automation shall be envisaged.
- All Annunciations shall have interfacing facilities with communication for SCADA.

6.4.10 Indicating Instruments & Meters

The instruments shall be of the electronic or digital type with an LCD display and shall be positioned at the top of the panel. These instruments should have a high-performance ratio and can be equipped with digital output (for alarms) or with interfacing facilities for communication and remote reading of parameters.

- **Metering Instruments**
- Multi-Function Meter with the facility to measure A, V, kW, kWh, kVAr, PF, kVARh, Hz and Hormonic (%THD) contents with communication port.
- Multi-function meters shall be of accuracy class 1.0, suitable for measuring unbalanced loads in three-phase, three-wire circuits.
- MFM shall be suitable for operation from the secondary of CTs and VTs. They shall be provided with separate 3-phase, 4-wire test blocks for testing the meters without disturbing the CT and VT secondary connections.

The instruments can be electronic/digital type with LCD & RS 485 connectivity for remote reading of parameters in SCADA. These instruments should have a high performance ratio and can be equipped with digital output (for alarms).

6.4.11 Control and Selector Switches

Control and instrument switches shall be heavy-duty rotary type, provided with escutcheon plates clearly marked to indicate the operating position, and suitable for semi-flush mounting, with only the switch front plate and operating handle projecting outward. The connections shall be from the back. The contact assembly at the back of the switch shall be enclosed in dust-tight, removable covers.

The control switches shall be 3 positions, spring return to neutral type. They shall be provided with contacts to close in 'normal after close' and 'normal after trip' positions. Each switch shall have external red and green indicating lamps, (except when discrepancy type switches are called for). In addition, a semaphore indicator shall be provided for the earthing switch. Local / Off / Remote selector switch shall be a 2/3-position with a lockable provision.

Contacts of the switches shall be spring-assisted, and contact faces shall be of silver/silver alloy. Springs shall not be used as current-carrying parts. The contact rating and configurations of the switches shall be adequate for the desired functions.

Lockable type switches, which can be locked in a particular position, shall be provided, if required. Emergency stop buttons, if any, shall incorporate 'stay-put' features with independent reset facilities.

6.4.12 Indicating Lights / Pilot Lights

Indicating lights shall be rated for operation at either 230V AC or the specified DC system voltage, as applicable. Lights shall be provided with translucent light covers.

Clustered LED-type lamps shall be provided. Lenses shall be glass or plastic in standard colours, red, green, blue, white and amber, in accordance with IEC 60073. Miniature pilot lamps may be provided with a plastic marking plate contained inside a square (or rectangular) front lens to provide an indication of the legend or symbols engraved on the marking plate.

The basis of colors shall be as follows:

Red : Flow of energy.

Green : No flow of energy.

White : Supervision of power available, relay coil healthy, etc.

Amber : For all alarm conditions such as pressure low, overload, Disagreement with original condition, 'abnormal' condition or 'sequence - on' condition also for service and test position.

Blue : For all healthy conditions such as control supply, spring charged and lockout relay coil healthy.

Yellow : For R, Y, B indication light, yellow as one of the lights.

6.4.13 Push Buttons

Push buttons shall be of a momentary contact type with rear terminal connections. The colour of the push button actuator shall be red for 'OPEN / STOP' and green for 'CLOSE / START'. The push button knob shall be suitably shrouded to prevent inadvertent operation. The push buttons shall be provided with integral inscription plates engraved with their designation.

The normal stop push button shall be a mushroom-type latchable in red colour. After pressing, it shall latch, and the latch can be removed by clockwise rotation. The motor stops automatically under predetermined conditions, such as when the delivery valve closes in the case of pumps. This may replace the stop push button.

The emergency stop push button, red in colour, shall be lockable by pressing the push button and can be opened only with the key and with the shrouding. (Motor stopped immediately irrespective of predetermined conditions required) An emergency push-button with shrouding shall be provided near the transformer and motors for remote tripping.

The reset push button shall be either for resetting the flag and OLR or LEDs with a push button for resetting.

All push buttons shall have independent, potential-free, 2NO + 2NC contacts. The contact faces shall be of silver / silver alloy. The contacts shall be rated 10A and capable of breaking an inductive load of 5A at 110V DC.

All push buttons shall have additional NO / NC potential-free for hard wiring to the instrumentation control panel.

6.4.14 Space Heaters

Adequately rated anti-condensation space heaters shall be provided for each switchboard/cubicle, bus ducts. The space heater shall be of the industrial strip, continuous-duty type, rated for operation on a 240V, 1-phase, 50Hz AC system.

Space heater shall be provided with a single pole 16A, MCB, 240V AC with overload and short circuit release, a neutral link, and an RTD thermostat to cut off the heaters at 35-degree °C.

6.4.15 Cubicle Lighting / Receptacle

Each cubicle shall be provided with interior lighting using an 18-W energy-efficient (lumen per watt shall be indicated) LED lighting fixture. An MCB shall be provided for the lighting circuit. The lighting fixture shall be suitable for operation from a 240V, 1-phase, 50Hz AC supply. A 240V, 1-phase, AC receptacle (socket) plug point shall be provided in the interior of each panel with an MCB.

6.4.16 Power and Control Cable Termination

Terminals for power connections shall be complete with adequate phase-segregating insulating barriers, shrouds, and suitable aluminum solder-less crimping-type lugs for terminating the cables. Control cable lugs and ferrules shall be tinned copper, conforming to IS 8309. The cable lugs for control cables shall be provided with an insulating sleeve and shall be compatible with the type of termination provided on the equipment.

Double compression type glands with armour and bonding clamps for the termination of all solid dielectric multicore cables shall be provided and shall conform to BS:6121. They shall be designed to secure the armour wires to provide electrical continuity between the armour and the threaded fixing component of the gland and to provide watertight seals between the cable outer sheath and gland and between the inner sheath and the threaded fixing component. The gland shall preferably project above the gland plate (non-magnetic material) to avoid entry of moisture.

Earthing connectors between cable armour and earth shall be routed outside the cable gland in an approved manner. Gland insulation shall be capable of withstanding a test for an appropriate high voltage for one minute.

Cable terminations for HV / MV cables shall be heat / cold shrinkable type. Adequately sized shrouds/bolts shall be provided at connections to cover the terminations completely.

Where core balance type current transformers are provided on the feeder cables for earth fault protection, glands for cables shall be insulated from earth in an approved manner.

Knock-out holes of appropriate size and number shall be provided in the panels in conformity with the location of incoming and outgoing cables.

6.4.17 Wiring for Control and Protective Circuits

All low voltage wiring for control, protection, and indication circuits shall be carried out with 1100V grade, PVC insulated cable with stranded, tinned copper conductor of minimum 1.5 sq mm size. The size of the conductor for CT circuits shall be a minimum of 2.5 sq. mm.

All wiring shall be run on the sides of panels and shall be neatly bunched and cleated without affecting access to equipment mounted in the panel. The wiring shall be bound and supported by clamping, roughing, or lacing. Spiral wrapping shall not be accepted. Wireways shall not be more than 50% full. Adequate slack wire shall be provided to allow for one re-stripping and reconnection at the end of each wire. When screened cables or wires are necessary, an insulating sheath shall be included. Wiring and supports shall be of fire-resistant material.

Wiring shall only be joined or tied at terminals. Terminals of the clamp type shall not have more than two wires connected.

6.4.18 Termination and Ferrules

Engraved core identification ferrules, marked to correspond with the wiring diagram, shall be fitted to each wire and each core of multicore cables terminated on the panels.

Moisture and oil-resistant insulating material shall be used. The ferrules shall be of the interlocking type and shall grip the insulation firmly without falling off when the wire shall be removed.

All wires forming part of a tripping circuit shall be distinctively marked. Spare auxiliary contacts of electrical equipment shall be wired to terminal blocks.

6.4.19 Control Wiring Terminal Blocks

Terminal blocks shall be of 1000V grade, 10A, and stud type. Brass stud of at least 6 mm dia. with fine threads shall be used and securely locked within the mounting base to prevent turning. Each terminal shall comprise two threaded studs, with a link between them, washers, and matching nuts and locknuts for each stud. Connections to the terminals shall be at the front.

Terminals shall be numbered for identification, grouped according to function. Engraved ‘black on white’ labels shall be provided on the terminal blocks, describing the function of the circuit.

Terminals for circuits with voltage exceeding 110V shall be shrouded. Terminal blocks at different voltages shall be segregated into groups and distinctively labelled. Terminals used for connecting current transformer secondary leads shall be ‘disconnecting and shorting’ type with a facility for earthing the secondary.

Terminal blocks shall be arranged with 100 mm clearance, between any two sets. Separate terminal stems shall be provided for internal and external wiring respectively. All wiring shall be terminated on terminal blocks, using crimping type lugs or claw-type terminations.

At least 20% cores shall be kept spare in multicore control cables. At least 10% spare terminals shall be provided and space for adding another 10% spares terminals shall also available in each set of TBs.

6.4.20 Bus Bars

The Bus bars shall be made of electrical-grade, high-conductivity copper and shall be provided with a minimum clearance as per the relevant IS. The bus bar cross-section shall be uniform throughout the length of the switchgear. All busbars and bus taps shall be insulated with a close-fitting sleeve of hard, smooth, dust and dirt-free, heat-shrunk PVC insulation of high dielectric strength, to provide a permanent, non-ageing, and non-tracking protection, impervious to water, tropical conditions, and fungi.

The insulation shall be a non-inflammable and self-extinguishing type and in fast colours to indicate phases. The dielectric strength and properties shall hold good for the temperature range of 0 to 95 degree centigrade. If the insulating sleeve is not coloured, bus bars shall be colour coded with coloured PVC tape at suitable intervals for easy identification.

Busbar joints shall be of the bolted type. Spring washers shall be provided to ensure good contact at the joints. Busbars shall be thoroughly cleaned at the joints and suitable contact grease shall be applied just before making a joint. Direct access to, or accidental contact with busbars and primary connections shall not be possible.

All apertures and slots shall be protected by baffles to prevent accidental shorting of busbars due to insertion of maintenance tools.

The sequence of red, yellow, and blue phases and neutral for four-pole equipment shall be left to right and top to bottom, for horizontal and vertical layouts, respectively.

End terminations at the transformer end and the MV panel end shall be flexible bus bars such that no load / force / weight of the bus bar acts on the terminal studs.

6.4.21 Current & Voltage Transformers

Current transformers shall be of cast resin, bar primary type unless specified otherwise, with burden of 100VA and accuracy class of 0.5, suitable for continuous operation at the ambient temperature prevailing inside the switchgear enclosure, and shall have polarity markings indelibly marked on each transformer and at the lead terminations at the associated terminal block. The class of insulation shall be Class E or better. CTs shall be provided on the incoming side of each panel set and shall be star/star connected.

Current transformers shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit and momentary duties of the switchgear. For wound primary type CTs, the short-time current rating shall not be less than 0.5 seconds. CT core laminations shall be of high-grade silicon steel. Where multi-ratio current transformers are specified, a label shall be provided that clearly indicates the connections required for the alternative ratios.

These connections shall also be shown on panel wiring diagrams. Identification labels shall be fitted, giving type, ratio, rating, output, and serial numbers, and duplicate rating labels are to be fitted on the exterior of the mounting chambers, suitably located to enable reading without the removal of any cover or metal sheeting forming part of the structure of the switchboard.

Magnetization characteristics calculated performance and protective settings shall be provided by the contractor. All Voltage Transformers shall be of the Single-Phase type. The bus VTs shall be housed in a separate panel in a truck so as to be fully with drawable. All Voltage transformers shall have HRC fuses / MCBs on Primary and MCBs on Secondary Side. There shall be provision for changeover on

secondary side of Voltage Transformers to have alternate arrangement in case one Voltage Transformer fails.

6.4.22 Relays

(a) All Protective relays shall be numerical type except aux. relays. Numerical relays shall have appropriate setting ranges, accuracy, resetting ratio, transient overreach, and other characteristics to provide required sensitivity.
(b) All numerical protective relays shall be flush-mounted at the front with connections at the rear. Shall have a communication port for remote, metering, and monitoring facility, suitable for electrical measurement including voltage, current, power (active/reactive), and energy parameters.
(c) All numerical relays shall have a keypad to allow relay settings from the relay front. Resetting knobs shall be accessible from the front on removing the external cover and shall be external to the case.
(d) All numerical relays and timers shall be rated for the control supply voltage specified and be capable of satisfactory continuous operation between 70% and 110% of the rated voltage. Making, Carrying and Breaking Current ratings of the relay contacts shall be adequate for the circuits in which they are used.
(e) The numerical relays shall have communication, metering, and monitoring facilities. The communication facility shall have two Ports: a local front port (RJ45/USB) for laptop communication and a Rear RS-485 port for SCADA.
(f) The numerical processor shall be capable of measuring and sharing values of a wide range of quantities, events, faults, and disturbance recordings, with time-stamping using an internal real-time clock. Battery backup for the real-time clock shall be provided in the event of a power failure.
(g) Numerical Relays shall have a diagnostic feature with self-check for power failure, Programmable routines, memory, and main CPU Failures, etc.
(h) The Protective relays shall have an adequate number of potential-free contacts (Programmable). The Contacts shall be suitable for directly wiring in the breaker closing and tripping circuits operating from 110V DC Control Voltage.
(i) The current operated relays shall have provision for 4 Sets of CT Inputs and Voltage operated relays shall have provision for 3 PT inputs. Relays shall be suitable for CT secondary current of 1A / 5A, selectable at the Site.
(j) Numerical Relays shall be immune to any electromagnetic interference and capacitance effect due to length of connected control cables.
(k) Timer function shall be programmable for ON / OFF delays.
(l) Numerical Relays shall be able to provide supervisory function such as trip circuit monitoring, circuit breaker monitoring, PT & CT supervisions and recording facilities with post fault analysis.
(m) All relays shall withstand minimum test voltage of 2kV AC RMS for one minute.
(n) Numerical relays shall have two level password protections, one for read only and other for authorization for modifying the setting etc.

6.4.23 Energy monitoring and power supply management

Necessary provisions & features shall be incorporated to enable energy monitoring / energy management for the installation. Energy Metering shall meet the requirement of guaranteed specific energy consumption specified by the contractor through instrumentation control system.

In case, Numerical relays having built in features of energy measurement of requisite accuracy and provided in switch gear, separate energy meter shall not be required.

Necessary provision & features shall be incorporated to under voltage monitoring / relay for incomer feeder, busbar chamber and control supply.

6.4.24 Tests

All type test and routine tests shall be carried out in accordance with IS 62271 standard.

6.4.25 I/O signal for Instrumentation, Control & Automation System from Electrical panels.

I/O signals from instruments shall be separately wired to a marshalling box, so that instrumentation engineers do not need to enter power panels that are unfamiliar to them.

Necessary provisions shall be incorporated to meet the requirements indicated in:
(a) I/O Schedules – ACB/VCB, Command Open/Close, Feedback Trip, Breaker Healthy (Ready to Close), Local/Off/Remote, Breaker Open/Closed, Breaker Test/Service Position.
(b) Data Transfer Schedule
(c) Alarm Schedule, as outlined in Part 13 of the specific requirements for the Instrumentation, Control, and Automation System, and Volume 2 of the Bid document.

6.4.26 Drawings and Data

All Drawings, data, technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates of typical transformer etc shall be submitted along with the bid / after award of contract as specified under “Bid / Contract Drawings”, Part 3, General Requirements, Volume - 2 of Bid Documents.

6.5 415V Metal Enclosed Switchgears (PCC / MCC)

The 415V metal-enclosed switchgear (PCC/MCC) system shall have provisions for interoperability with the instrumentation control system. MCC / PCC panel boards shall be offered for final inspection at the OEM’s works with routine tests.

6.5.1 Applicable Standards

The switchgear and components shall conform to the latest applicable standards specified below.

Low-Voltage Switchgear and Control gear (All Parts)	IS/IEC 60947 / BS:5486 / IEC:60947
Low-voltage Switchgear and Control gear assemblies (All Parts)	IS/IEC:61439
Moulded Case Circuit Breaker	IS:2516 / IEC 60947-2 / BS EN:60947-2 / IS/IEC 60947
Miniature Circuit Breakers	IS:8828 / BSEN:60898
Low voltage Fuses	IS:13703 / BS:1362 / IEC:60269 - 1
Contactors	IS/IEC :60947 / BS EN60947 - 4 / IEC:60947 -1
Starters	IS/IEC:60947 / BS EN60947 – 4 / IEC:60292 -1 to 4
Control Switches / Push buttons	IS:6875 / BSEN 60947
Instrument Transformers	IS 16227 / IEC 61869 / IS/IEC 60044
Indicating instruments	IS:1248 / BS:89 / IEC:60051

Electrical relays.	IEC:60255
Marking and Identification of Conductors and Apparatus Terminals	IS:11353/BS:159
A.C. Electricity Meters	IS:722, 8530 / BS:5685 / IEC:60145, 60211
Degree of Protection	IS/IEC: 60947 / IEC:60947
Selection installation and maintenance of switchgear and control gear	IS:10118
Code of practice for phosphating coated iron and steel	IS:6005 / BS:3189
Specification for copper rods and bars for electrical purposes	IS:613
Control transformers for switchgear and control gear voltage not exceeding 1000V AC	IS:12021
Classification of Hazardous areas having Flammable gases and vapours for Electrical Installation	IS:5572
Explosive Atmospheres-Electrical Installations Design, Selection and Erection	IS 16724: 2018
Electrical apparatus for explosive gas atmospheres-General Requirements	IEC:60079
Basic and Safety Principles for Man-Machine Interface, Marking and Identification - Coding Principles for Indicators and Actuators.	IEC:60073
Conductors of Insulated Cables.	IEC:60228
Dimensions of low-voltage switchgear and Control gear. Standardized mounting on rails for mechanical support of electrical devices in switchgear and Control gear installations.	IEC 60715
Graphical symbols for use on equipment.	IEC:60417
Electricity metering equipment	IEC:62052-11 / IEC 62052 - 21
Empty enclosures for low-voltage switchgear and Control gear assemblies General requirements and Control gear assemblies General Requirements	IEC:62208

6.5.2 General

This section describes the general rules to guarantee maximum level of quality and performance for a LV switchboard hereafter named as LV switchboard or LV switchgear and control assembly, the combination of one or more low voltage switching devices together with associated control, measuring, signalling, protective, regulating equipment, with all the internal electrical and mechanical interconnections and structural parts.

LV switchboards will be produced as per standard IEC 61439-1&2.

The LV switchboards shall be type-tested assemblies (TTA Panels) in all respects, suitable for service operations and capable of withstanding the stresses of seismic conditions. The offered design shall meet the requirements of IEC 60068-2-57, & IEC 60068-3-3. Necessary type test report from an independent internationally accredited test laboratory shall be furnished to establish that the offered design performs satisfactorily in compliance to the reference standards.

The LV switchboards shall be type tested assemblies (TTA) fully meeting the requirements of IEC 61439 – 1 & 2 for design verified assemblies. The eligible switchboard suppliers shall be Original

Equipment Manufacturers (OEMs) only with their own range of ACBs, MCCBs, Power Contactors & other switchgear devices. The switchboards shall be manufactured, design & tested by OEM at their own works.

The LV main switchboards and the associated equipment, including switchgear, control gear and bus bar assemblies shall be certified for the category of duty specified. The LV Main Switchboard shall be identical in mechanical construction to the LV Switchboard, which had been type-tested by an acceptable, multi-fold design for structural members (9-fold design) with impact test as per IEC 62262, accredited and independent testing laboratory for the fault conditions, temperature rise limits. Any manufacturer not having the above will not be considered for supply. The main circuits of the LV main switchboards shall have an insulation voltage of 1000 V AC. Panels shall be tested to withstand an internal arc fault of 50kA, 0.4 seconds, and a valid Type Test Certification shall be provided as per IEC 61641.

The design temperature for the equipment provided in the main low-voltage switchboards shall be +45 °C. The relative humidity shall be 75% at a temperature of + 45 °C.

Where armoured multicore cables terminate inside the switchboard enclosure, glanding plates or glanding brackets shall be provided for securing the cables to the switchboard. Glanding plates, glanding brackets, and extension boxes shall be removable and of adequate size for the particular cables to be terminated. Separate current transformers shall be provided for each protection device and for instrumentation. The switchgear assembly / sub-assemblies or panels shall be termite and rodent-proof. The sub-assemblies of similar equipment shall be interchangeable.

Switchboards (TTA) shall also have Seismic withstand capability.

The offered switchboard along with Incomer ACBs / MCCBs and outgoing feeders with all interconnections shall be as per type-tested design of OEM at CPRI / ERDA / Independent international test house for short circuit, temperature rise, protective earth short circuit test, and dielectric tests of the ratings required.

For operator safety IP2X (touch proof) protection to be available even after opening the feeder compartment door. The compartmentalization to be achieved by using metal or FRP separators, use of PVC sheet / Hylem sheets shall not be allowed.

The Switchboards shall be of adequate size, with provision for spare space to accommodate possible future additional switchgear.

All assemblies will be verified in two stages of verification

Design Verification

To conform to standard IEC 61439-1 & 2, the manufacturer must successfully verify design requirements as specified below

Construction requirements:

1) Strength of materials and parts
2) Degree of protection of enclosures
3) Clearances and creepage distances
4) Protection against electric shock and integrity of protective circuits
5) Incorporation of switching devices and components
6) Internal electrical circuits and connections
7) Terminals for external conductors

Performance requirements:

8) Dielectric properties
9) Temperature rise
10) Short-circuit withstand strength
11) Electromagnetic compatibility
12) Mechanical operation

Routine verification

1) Degree of protection of enclosures
2) Clearances and creepage distances
3) Protection against electric shock and integrity of protective circuits
4) Incorporation of built-in components
5) Internal electrical circuits and connections
6) Terminals for external conductors
7) Mechanical operation
8) Dielectric properties*
9) Wiring, operational performance and function*

A conformity sheet, signed by the assembler, attesting to the completion of the routine tests, will accompany the LV switchboard up to its installation site.

*: The verification will be performed by a general inspection for the first 7 tests; the 2 remaining requirements must be tested by appropriate equipment.

Additional requirements on the design

The main LV switchboard must be designed to ensure a clear vision of the separation into the 3 divisions as per below:

1) switchgear and control gear installation
2) busbar network
3) connections and the insertion of feeder cables

Features of Constructions

(a) The switchgear shall be metal enclosed, dust proof, modular type, suitable for indoor floor mounting and shall have following features:
   (i) Total height of switchgear shall not exceed 2300 mm. The height of Switches and push buttons shall not exceed 1800 mm and shall be at least 600 mm.
   (ii) Shall be single front execution and fixed type.
   (iii) Shall have designation labels for feeder numbers and the designation suitably engraved white on black on metal both on front and rear sides.
   (iv) Shall be provided with proper gasketing for removable covers, doors, between panels and base frame and all around the perimeter of adjacent panels.
   (v) Degree of Protection shall be IP54 for indoor & IP55 for outdoor.
   (vi) Thickness of CRCA sheet panel doors shall be 2.5mm or over, and for the rest shall be 2.0mm.
   (vii) Stiffeners shall be provided wherever necessary to strengthen the door and side covers.

(viii) Shall follow IS 5572 / IEC 60079, standard specification and standard practice for installation in hazardous area.

(b) Switchgear shall be divided into distinct vertical sections, each comprising:
- (i) A completely enclosed busbar compartment running horizontally.
- (ii) Enclosed vertical busbars serving all modules in the vertical section.
- (iii) A separate horizontal enclosure for all auxiliary power and control buses, if required.
- (iv) Vertical cable alley of 250mm wide covering entire height.
- (v) Operating devices shall be incorporated only in the front of switchgear.
- (vi) Each shipping section shall have metal sheets at both ends.
- (vii) Cable alley shall be provided with suitable hinged doors.
- (viii) A copper earth busbar of the required size, suitable for the short-circuit level of the switchgear, shall be provided at the bottom.
- (ix) All doors shall be with concealed type hinges and captive screws.
- (x) Each vertical section shall be equipped with 240V, 1Phase, 50Hz space heater controlled by thermostat.
- (xi) A 240V, Phase, AC plug point shall be provided in the interior of each cubicle with on-off switch for correction of head lamps.
- (xii) 20% spare feeders with at least one for each type of highest rating shall be provided in each switchgear.
- (xiii) Interchangeability - All identical equipment and corresponding parts be fully interchangeable without any modifications.

(c) Main and Auxiliary Buses
- (i) Switchgear busbars shall be of uniform cross-section throughout their length and made of high-conductivity, electrical-grade, hard-drawn copper conductor with a minimum cross-sectional area of 1.60Amp / Sq. mm current density throughout the length.
- (ii) All busbars shall be insulated with a close-fitting sleeve of hard, smooth, dust- and dirt-free, heat-shrunk PVC insulation of high dielectric strength, providing permanent, non-ageing, and non-tracking protection, impervious to water, tropical conditions, and fungi.
- (iii) Busbar joints shall be provided with contact grease at the joints and shall be complete with tensile steel bolts and Belleville washers and nuts.
- (iv) All sheet steel work shall be phosphate coated in accordance with the following procedure and in accordance with IS: 6005 “Code of Practice for Phosphate coated Iron and Steel”. Oil, grease, dirt and swarf shall be thoroughly removed by emulsion cleaning. Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.
- (v) After phosphate coating, thorough rinsing shall be with clean water, followed by final rinsing with dilute dichromate solution and even drying. The phosphate coating shall be followed by the application of two coats of ready mixed stoving-type zinc chromate primer. The first coat may be “flash dried” while the second coat shall be stoved. After application of the two coats of primer finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied after completion of tests. The final finished thickness of the paint film on steel shall be between 80 microns and 120 microns.
- (vi) The finished painted surface of panels shall present an aesthetically pleasing appearance free from dents and uneven surfaces.
- (vii) A small quantity of finishing paint shall be supplied for minor touching up required at site after the installation of the panels.

(d) The equipment shall be arranged within each compartment such that all normal maintenance can be carried out through hinged access doors or removable covers, and where possible from the front. The switchboard shall have a rated short time withstand current as per SLD and a fault withstand for a supply voltage of (415V) AC between phases at 50Hz.

(e) Protection against shock in normal service shall be achieved by the provision of barriers or enclosures both vertical and horizontal and between adjacent units to ensure segregation and prevent accidental contact with live parts, or by complete insulation of all live parts. Control cables shall be segregated from primary conductors.

(f) Switchboard construction shall employ the principle of compartmentalized and segregation for each circuit.

(g) Incomer and bus section panels or sections shall be separate and independent and shall not be wired with sections required for feeder

(h) Switchboard shall be readily extensible on both sides by addition of vertical sections after removal of the end covers.

(i) Special care to be taken to ensure effective earthing of the frame and doors of the switchboards. All metallic parts shall be effectively connected a protective earth system in the switchboard to ensure positive earthing at all times.

(j) All panels and covers shall be properly fitted and square with the frame. The holes in the panel shall be correctly positioned.

(k) Switchboard shall be provided with "Danger Notice Plate" conforming to relevant Indian Standards.

(l) The LV switchboards shall be mounted on a robust base frame made up of steel channels with a minimum height of 100mm. The base frame shall be capable of withstanding the static and dynamic loads of the low-voltage switchboards. The steel channels shall be painted with epoxy polyester paint.

(m) For compartmentalized switchboards, separate enclosed compartments shall be provided for horizontal busbars, vertical busbars, ACBs, MCCBs, and cable alloys.

(n) Cable compartments shall be of adequate size for easy termination of all incoming and outgoing cables entering from the top. The construction shall include necessary and adequate support, and proper support shall be provided in cable compartments to support and clamp the cable in the cable alley/cable chamber.

6.5.3 Air Circuit Breaker (ACB)

(a) Air circuit breaker shall be selected for feeders for load current more than 630A.

(b) A motor spring-charging type mechanism shall operate circuit breakers. The motor-operated spring-charged mechanism shall be complete with a motor, opening spring, closing spring, and all necessary accessories to make the mechanism a fully operational unit.

(c) The tripping spring shall be charged by the closing action, to enable quick tripping. Closing of the circuit breaker shall automatically initiate recharging of the springs to enable the mechanism to be ready for the next closing stroke. Charging time for the springs shall not exceed 30 seconds. It shall be possible to charge the springs in an emergency manually.

(d) Transfer from motor to manual charging shall automatically disconnect the charging motor. The charging mechanism shall be provided with mechanical indicators to show "charged" and "discharged" conditions of the spring. Failure of any spring, vibration or mechanical shock shall not cause tripping or closing of the circuit breaker.

(e) Only one closing operation of the circuit breaker shall result from each closing impulse (manual or electrical), even if the breaker trips while the control device (manual or electrical) is being held in the "close" position.

(f) The circuit breaker mechanism shall make one complete closing operation, once the push button has been operated and the first device in the control scheme has responded, even though the PB shall be released before the closing operation shall be completed, subject to the condition that there is no counter-impulse for tripping.

(g) Means shall be provided to manually open and close the breakers slowly, when the operating power shall not be available, for maintenance and adjustments. A local manual trip device shall be provided on the operating mechanism.

(h) All operating mechanisms shall be provided with "ON" - "OFF" - "TRIP" mechanical indication.
(i) Closing coils and other auxiliary devices shall operate satisfactorily at all voltages between 85 - 110% of the control voltage. Trip coils shall operate satisfactorily between 70 - 110% the rated control voltage.
(j) The ACB shall be 4 pole with modular construction, draw out, manually operated. In case of a 4-pole version, the neutral rating shall be 100% of the phase.
(k) The Breaker shall be equipped with a microprocessor-based Protection unit featuring inverse-time delayed overload releases for the phases, Short-time delayed short-circuit releases, and earth-fault releases.
(l) The breaker service Short-Circuit breaking capacity (ICS) shall be equal to the ultimate short-circuit capacity (ICU) and shall be equal to the short-time withstand current of the Breaker (I_{CW}).
(m) ACB shall be provided for the Incoming side of the PCC / MCC from the transformer, irrespective of the rating of the feeder.
(n) The cradle shall be so designed and constructed as to permit smooth withdrawal and insertion of the breaker into it. The movements shall be free from jerks, easy to operate, and shall be on steel balls/rollers and not on flat surfaces.
(o) There shall be provision for locking the breaker in any of the Service, Test, or Isolated positions.
(p) ACB shall be supplied with 4 auxiliary contacts (combinations of NO / NC shall be selected at site) and 1 trip contact. If need arises, there shall be a facility to add additional auxiliary contacts (6 in number).
(q) ACB shall have provision to use `Ready to Close' contact.
(r) The safety shutter shall prevent inadvertent contact with isolating contacts when breaker is withdrawn from the Cradle.
(s) Arc Chute covers wherever necessary shall be provided.
(t) ACB shall have a Ready to close indication contact which shall be used to give a single indication via indicating lamps on panel door if ACB is ready to be closed, after checking all the given conditions ensuring safety for user and electrical distribution.

6.5.4 Intelligent Motor Protection Relay

The intelligent motor controller for 3-phase AC induction motors combining the two classical functions of motor protection and motor management in a single device plus offering diagnostic and fieldbus communication. The device's functions shall be adjustable over a wide range to cater to the needs of various applications.

Protection Functions:
It shall be provided motor protection including phase failure detection, adjustable motor protection for stalled motors during start up or normal operation, configurable current limits to generate trips or warnings with following features:
(a) Overload classes.
(b) Thermistor motor protection (PTC).
(c) Earth fault detection.
(d) Power and voltage-based protection functions.
(e) Supervision of the network quality (Total Harmonic Distortion)

Field Bus Communications:
(a) It shall be integrated into different fieldbus networks such as PROFIBUS DP, Device Net MODBUS and CAN open via the Fieldbus Plug interface. All measured data, status signals and parameters shall be accessed via fieldbus.
(b) It is also possible to use the as a stand-alone device without the Fieldbus Plug communication.
(c) The motor protection and motor management is fully functional in the event of a bus failure

Parameterisation of the protection and control functions can be carried out with the device description files as defined by the different fieldbuses (e.g. GSD for PROFIBUS). Additionally, a Device Type Manager (DTM) is required that offers a convenient device configuration option via a laptop or within a control system.

Motor Management, Inputs and Outputs
It shall be provided six digital inputs, three relay outputs and one 24 V output. Therefore, a wide number of control functions shall be covered from the base device. If further inputs or outputs are needed, the basic device can be expanded with an expansion module. The relay shall support standard configurations, such as direct starter, reversing starter, star-delta starter, actuator, inching mode, and many more features. To execute customer specific applications & allows free programming of its internal logic.

Different control stations (DCS, DI, and Operation Panel) with individual, adjustable release opportunities are required.

Metering, Monitoring and Diagnosis
Rapid, comprehensive diagnostics and operating status information shall be available on the on the LCD panel (clear text messages), via fieldbus or on a laptop connected directly or via fieldbus to the relay.

The fully graphic, multi-language LCD panel allows configuration, control and monitoring of the controller and its inputs and outputs.

Available diagnosis includes motor, bus and device status, maintenance counters such as number of starts and overload releases, remaining cooling time, etc.

6.5.5 Moulded Case Circuit Breaker (MCCB)

All MCCBs shall be of the air-break, quick-make, quick-break, and trip-free type switching mechanism, with an arc extinguishing device. The tripping unit shall be contained in a compact, high-strength, heat-resistant, flame-retardant, and insulating moulded case with high withstand capability against thermal and mechanical stresses. All MCCB's shall be capable of Variable overload adjustment.

MCCBs shall have an ultimate short-circuit capacity not less than the short-circuit current Specified. MCCBs shall have a service short-circuit breaking capacity (ICS) equal to the ultimate short-circuit capacity (I_{CU}).

Each pole of MCCB shall be fitted with a bi-metallic thermal element for inverse time delay protection and a magnetic element for short circuit protection. Alternatively, they shall be fitted with a solid-state protection system. Such a protection system shall be fully self-contained, needing no separate power supply to operate the circuit breaker tripping mechanism.

Thermal element shall be adjustable. Adjustments shall be made simultaneously on all poles from a common facility. Thermal elements shall be temperature-compensated for ambient temperatures.

The Electronic / Microprocessor Trip Unit shall be equipped with an internal battery to power the display in no-load conditions.

The MCCBs shall be provided with the following features:
- Common trip bar for simultaneous tripping of all poles.
- Shrouded terminals.
- Time for clearing short circuit current of 20 msec.

- 2 NO + 2 NC auxiliary contacts suitable for switching 24V DC, 10mA PLC Signals with no loss of signal integrity.

MCCBs shall be actuated by an extended rotary-handle with pad lock arrangement that clearly indicates the three distinctive positions: ON, OFF and TRIPPED.

Adjustable overload releases for the phases, Adjustable Short-time delayed short-circuit releases and earth-fault releases. Rotary operated mechanism 240V AC Shunt trip Coil has to be provided. The manually closing mechanism should be accommodated in a moulded housing of robust and vermin-proof construction.

MCCB shall be provided with double insulation (insulation between the front cover and internal power circuits to prevent accidental contact with a live current-carrying path when the front cover is open). The insulating case shall be made of high-strength heat-resistant and flame-retardant thermosetting insulating material.

6.5.6 Switches

The 415V air-break switch shall be of the load-break, fault-make, group-operated type. For use on 3-phase systems, the switches shall be of the triple pole type with a link for neutral wire. For use on single phase system, the MCB type switches shall be of the two-pole type.

(a) Switches shall be of the heavy-duty, quick-make and quick-break type. Switch contacts shall be silver plated, and contract springs shall be of stainless steel. Switch handles shall have provision for locking in both fully open and fully closed positions. A mechanical ON-OFF indication shall be provided on the switches.
(b) Switches for controlling motor circuits shall be of the load-break, fault-make type, and shall be capable of breaking the locked-rotor current of the associated motor.
(c) 415V switches and fuses shall be provided with the following interlocks so that.
(d) The fuses are not advisable unless the switch shall be in is in a fully open condition.
(e) It shall not be possible to close the switch when the cover shall be open, but an authorized person may override the interlock and operate the switch. After such an operation, the cover shall be prevented from closing if the switch shall be left in the ‘ON’ position.
(f) Fuse less system shall be provided in case fuses required, fuses shall be of the HRC cartridge type, mounted on plug-in type of fuse bases. Fuses shall be provided with visible indicators to show that they have operated.
(g) Earthing and neutral lines in main supply circuits shall be of solid silver-plated copper and be of the bolted pattern.
(h) Fuses and links functionally associated with the same circuit shall be mounted side by side.

6.5.7 Miniature Circuit Breaker (MCB)

MCB shall be hand-operated, air-break, quick-make, quick-break type. Operating mechanisms shall be mechanically trip-free from the operating knob to prevent the contacts being held closed under overload or short-circuit conditions.

Each pole shall be fitted with a bi-metallic element for overload protection and a magnetic element for short-circuit protection. Multiple pole MCBs shall be mechanically linked such that tripping of one pole simultaneously trips all the other poles. The magnetic element tripping current classification shall be of the type suitable for the connected load. Unless otherwise specified, it shall be Type C. The short circuit rating shall be not less than that of the system to which they are connected.

6.5.8 Contactors

The power contactors used in the switchboard shall be of the air break, single throw, triple pole, electromagnetic type. Contactors shall be suitable for uninterrupted duty and rated for Class AC3 duty in accordance with the latest edition of IS/IEC 60947.

Operating coils of all contactors shall be suitable for operation on 240V, single phase, 50Hz supply. Contactors shall be provided with at least two pairs of NO and NC auxiliary contacts. Contactors shall not drop out at voltages down to 70% of coil rated voltage. Contractors shall be provided with a three-element, positive-acting, ambient-temperature-compensated, time-lagged, hand-reset type thermal overload relay with adjustable settings. The hand reset button shall be flush with the front door of the control module and shall be suitable for resetting the overload relay with the module door closed. Relays shall be either direct connected or CT operated. Overload relay and reset button shall be independent of the "Start" and "Stop" push buttons. All contactor shall all be provided with single phasing preventer (SPP).

Motor starters shall be complete with auxiliary energy meters, protective relays, timers and necessary indications such that inter-operability with the instrumentation system.

6.5.9 Current Transformers / CBCT

(a) Current Transformers shall be Cast Resin type.
(b) Current transformers shall have polarity markings indelibly marked on each transformer and at the lead terminations at the associated terminal block.
(c) Current transformers shall be able to withstand the thermal and mechanical stresses resulting from the maximum short-circuit and momentary duties of the switchgear, as specified in the Technical Specification.
(d) CT core laminations shall be of high-grade silicon steel.
(e) Identification labels shall be fitted giving type, ratio, rating, output and serial numbers.

6.5.10 Indicating Instruments & Meters

All indication instruments and watt hour meters shall be of the digital type and shall have an accuracy of Class 1.0. Digital type ammeters, voltmeters and multifunction energy meters shall have communication port RS485.

6.5.11 Indicating Lights

Indicating lights shall be of the cluster LED type, with low watt consumption. Indicating lamp shall be rated for operation at either 240V AC or at the specified DC system voltage as applicable. LED shall be provided with translucent lamp covers. Bulbs and lenses shall be interchangeable and easily replaceable from the front.

6.5.12 Push Buttons

"Start" and "Stop" push buttons shall be coloured green and red respectively. Stop Push Button shall be a lockable stay-put type with a Mushroom head without a key or an Emergency push button lockable in the OFF position and openable only with a key.

6.5.13 Space Heaters

Adequately rated anti-condensation space heaters shall be provided, one for each control panel, for each switchboard and for each marshalling kiosk. Space heater shall be of the industrial strip continuous duty

type, rated for operation on a 240V, 1-phase, 50Hz, AC system. Each space heater shall be provided with a single pole MCB with overload and short circuit release, a neutral link and a control RTD thermostat to cut off the heaters at 35 Deg. C.

6.5.14 Safety Arrangements

All terminals, connections, and other components, which may be "live" when the front access door is open, shall be adequately screened. It shall not be possible to obtain access to an adjacent cubicle or module when any door shall be opened. Components within the cubicles shall be labelled to facilitate testing.

6.5.15 Earthing of Switchboards / Panels

Each switchboard, control panel, etc. shall be provided with an earth busbar running along its entire length. The earth bus bar shall be located at the bottom of the board/panel.

Earth bus bars shall be of copper and shall be rated to carry the rated symmetrical short circuit current of the associated board/panel for one second, unless otherwise specified. Earth bus bars shall be properly supported to withstand stresses induced by the momentary short circuit current of value equal to the momentary short circuit rating of the associated switchboard/panel.

A positive connection of the frames of all equipment mounted in the switchboard to the earth bus bar shall be maintained through insulated conductors of a size equal to or greater than the earth bus bar or the load current-carrying conductor, whichever is smaller.

All instrument and relay cases shall be connected to the earth bus bar by means of a 1100V grade, green-colored, PVC-insulated, stranded, tinned copper conductor looped through the case earth terminals.

6.5.16 Internal Wiring

The internal wiring shall be carried out using 650/1100V grade, PVC-insulated, stranded conductor wires. The minimum size of the conductor for power circuits shall be a 4 sq. mm copper conductor. Control circuits shall be wired with copper conductor of at least 1.5 mm^2.

6.5.17 I/O for Instrumentation, Control & Automation System from Electrical panels.

I/O signals from instruments shall be wired to a marshalling box of MCC / Switch gear such that instrumentation engineers shall not enter into the power system panels that they are not familiar with. Necessary provisions shall be incorporated to meet the requirements indicated in:

(a) I/O Schedules – ACB / VCB, Command Open & Close, Feedback trip, Breaker healthy (Ready to close), Local / Off / Remote, Breaker Opened / Closed, Beaker Test / Service position feedback.
(b) Data Transfer Schedule.
(c) Alarm Schedule of Particular requirement of Instrumentation, Control & Automation System, Part - 13, and Volume 2 of the Bid document.

6.5.18 Drawings and Data

All Drawings, data, technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates of typical transformer etc. shall be submitted along with the bid / after award of contract as specified under "Bid / Contract Drawings", Part 3, General Requirements, Volume - 2 of Bid Documents.

6.6 Power capacitor and APFC control panel (415V)

6.6.1 Applicable Standards

The capacitor and control panel conform to the latest applicable standards specified below. In case of conflict between standards and this specification, this specification shall govern.

Shunt capacitors for power systems	IS: 13585, IS: 13340
Internal fuses and internal overpressure disconnections for shunt capacitors - Specification	IS: 12672
Metal enclosed switchgear	IS/IEC 60947/ BSEN 60298 / IEC: 60298
Code of practice for phosphate coated iron and steel	IS: 6005 / BS: 3189
Specification for copper rods and bars for electrical purpose	IS: 613

6.6.2 Design Features

(a) The capacitor banks shall be complete with all necessary or essential parts for efficient operation. Such parts shall be deemed to be within the scope of supply whether specifically mentioned or not.

(b) The capacitor bank shall be complete with the required capacitors along with the supporting post insulators, steel rack assembly, copper bus bars, copper connecting strips, foundation channels, fuses, fuse clips, etc. The steel rack assembly shall be hot dip galvanized.

(c) The capacitor bank may comprise a suitable number of single-phase units in a series-parallel combination. However, the number of parallel units in each series rack shall be such that the failure of one unit does not create an overvoltage on the units in parallel with it, which would result in the failure of the parallel units.

(d) The complete capacitor banks with its accessories shall be metal enclosed (in sheet steel cubicle), indoor floor mounting and free-standing type.

(e) Stiffeners shall be provided wherever necessary to strengthen the door and side covers.

(f) All sheet steel work shall be thoroughly cleaned of rust, scale, oil, grease, dirt and swarf by pickling, emulsion cleaning etc. The sheet steel shall be phosphate-coated and then painted with two coats of zinc-rich primer paint. After application of primer, two coats of finishing synthetic enamel paint, oven-baked / stove-baked, shall be applied.

(g) The assembly of the banks shall be such that it provides sufficient ventilation for each unit. Necessary exhaust fan, louvers with filters must be provided in the cubicle to ensure proper ventilation for heat dissipation.

(h) Each panel shall be provided with 240 Volts, 1 phase, 50Hz, 5 amps, 3 pin receptacles with the switch located in a convenient position. An interior illuminating CFL / LED lamp together with the operating door switch and protective fuses shall be provided.

(i) Each capacitor unit / bank shall be fitted with directly connected continuously rated, low loss discharge device to discharge the capacitors to reduce the voltage to 50 volts within one minute in accordance with the provisions of the latest edition of IS: 2834.

(j) Capacitors shall be of mixed dielectric, consisting of polypropylene and paper, with internal element fuses. The impregnate shall be non-PCB (poly chlorinated biphenyl) oil.

(k) Each unit shall operate satisfactorily at 135% of its rated KVAR, taking into account factors such as overvoltage, harmonic currents, and manufacturing tolerance. The units shall be capable of continuously withstanding satisfactorily any overvoltage up to a maximum of 10% above the rated voltage, excluding transients.

(l) Each capacitor unit/bank shall be fitted with a directly connected continuously rated, low-loss discharge device to discharge the capacitors to reduce the voltage to 50 volts within one minute upon disconnection, in accordance with the provisions of the latest edition of IS:2834.

(m) APFCR panel shall have suitable detuned reactors for harmonic filtration in case of PMCC connected with VFD or Soft Starters.

(n) The PFC system shall be provided to achieve a power factor of not less than 0.98.

(o) Unit Protection

Each capacitor unit shall be individually protected by an HRC fuse suitably rated for load current and interrupting capacity, so that a faulty capacitor unit shall be disconnected by the fuse without causing the bank to be disconnected. Thus, the fuse shall disconnect only the faulty unit and shall leave the rest of the units undisturbed. An operated fuse shall give visual indication so that it may be detected during periodic inspection. The fuse braking time shall co-ordinate with the pressure built up within the unit to avoid explosion. Mounting of the individual fuse may be internal or external to the capacitor case.

The Inputs to the APFC system is voltage input from two phases and current input from the third phase. Out of two phases of voltage one phase voltage is taken as Reference 0 and another phase voltage as 440V. APFC needs to be installed with a CT (Current Transformer) on the third phase at the main incomer ACB after the transformer, which shall give a signal to the APFC Relay. Based on these inputs, the ASIC (Application Specific Integrated Circuit), OR call it a Microprocessor internal to the APFC Relay, shall give an output signal to the relay outputs, which shall energize the coil of the contactor, so that the contactor comes in line, connecting the capacitor bank in the circuit. However, this is step correction means PF shall be corrected in steps. The Voltage rise due to connection of capacitor banks is marginal. There shall be no frequency correction with the APFC System, and the APFC Relay shall have a communication port (RS-485).

6.6.3 Power Capacitor and Control Panel

(a) Power capacitor and control panel shall be housed in a metal-enclosed cubicle. Power capacitor shall be housed in the lower compartment and capacitor control panel at top compartment.

(b) The control equipment, including capacitors, shall be mounted in a panel of cold-rolled sheet steel. The panel shall be of indoor type and shall consist of:

- Busbars shall be made of copper conductor, hard-drawn (HD) and of high conductivity. All buses shall be insulated with a close-fitting sleeve of hard, smooth, dust- and dirt-free, heat-shrunk PVC insulation of high dielectric strength, providing permanent, non-aging, and non-tracking protection that is impervious to water, tropical conditions, and fungi.
- Isolating switch.
- Contactor with overload element.
- APFC Relays responsive to current / voltage / kVAR / PF as specified for automatic switching shall be microprocessor-based and suitable for both state board Electricity and DG sets with reduced power factor.
- Sequencing devices, timers and auxiliary relays for automatic sequential switching of the capacitors in and out of the circuit.
- Auto-manual selector switches.
- Push button for opening and closing the power circuit.
- Red and green cluster LED lights for capacitors ON / OFF indication.
- Protective numerical relays to protect the healthy capacitor units when one unit fails in a series connection.
- Space heater and cubicle lighting as per the requirements.

6.6.4 Drawings and Data

All Drawings, data, technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates of typical transformer etc shall be submitted along with the bid / after award of

contract as specified under "Bid / Contract Drawings", Part 3, General Requirements, Volume - 2 of Bid Documents.

6.7 Soft Starters

6.7.1 Applicable Standards

The design, manufacture and performance of equipment shall conform to the latest standards specified below.

Switchgear General Requirements (All parts)	IS/IEC:60947 / BS:5486 / IEC:60947
Factory Built Assemblies of SWGR and Control gear for Voltages up to and including 1000V AC & 1200V DC	IS/IEC 61439/ BS:5486 / IEC:61439
Air Break Switches	IS/IEC:60947 / BSEN60947 / IEC:60947-3
Moulded Case Circuit Breaker	IS 2516 / IEC 60947-2 / BS EN 60947-2
Miniature Circuit Breakers	IS:8828 / BSEN:60898
Low voltage Fuses	IS:13703 / BS:1362 / IEC:60269-1
Contactors	IS/IEC:60947 / BS EN60947-4 / IEC:60947-1
Starters	IS/IEC:60947 / BS EN60947-4 / IEC:60292-1 to 4
Control Switches / Push buttons	IS:6875 / BSEN 60947
Instrument Transformers	IS 16227 / IEC 61869 / IS/IEC 60044
Indicating instruments	IS:1248 / BS:89 / IEC:60051
Marking and Identification of Conductors and Apparatus Terminals	IS:11353 / BS:159
A.C. Electricity Meters	IS:722, 8530 /BS:5685 / IEC 60145,60 211
Degree of Protection	IS/IEC:60947 / IEC:60947-P1
Selection installation and maintenance of switchgear and control gear	IS:10118
Code of practice for phosphating coated iron and steel	IS:6005 / BS:3189
Specification for copper rods and bars for electrical purposes	IS:613
Control transformers for switchgear and control gear voltage not exceeding 1000V AC	IS:12021
Classification of Hazardous areas having Flammable gases and vapours for Electrical Installation	IS:5572
Explosive Atmospheres-Electrical Installations Design, Selection and Erection	IS 16724: 2018

Electrical apparatus for explosive gas atmospheres-General Requirements	IEC:60079

6.7.2 Constructional and Performance Features

(a) The Soft start panel shall be indoor, metal-clad, floor-standing, compartmentalized, complete with reactors, busbars, vacuum contactors, control, metering, protection equipment, and indicating lamps, etc.
(b) Stiffeners shall be provided wherever necessary to strengthen the door and side covers.
(c) The Soft starter shall achieve smooth starting by torque control for gradual acceleration of the drive system, thus preventing jerks and extending the life of the equipment.
(d) Protection shall be provided for soft starters (semiconductor fuse).
(e) The starting current shall be limited to 3.0 times the full-load current of the motor.
(f) The Soft starter shall have the possibility for low-speed forward and backward operation for positioning of a motor.
(g) The Soft starter shall have built-in diagnostics, fault detection and fault history.
(h) The Soft starter shall integrate motor and load protections, which shall under no circumstances be disabled when the integrated bypass shall be used. The following motor protections available along with warning function:
i) Electronic overload protection.
ii) Locked rotor protection.
iii) Motor under load protection.
iv) Current imbalance protection.
v) Voltage imbalance protection.
vi) Overvoltage & under voltage protection.
vii) Phase reversal protection.
viii) Total harmonic distortion (THD).
ix) Fans fault.
x) Thyristor overload.
xi) Number of starts.
xii) Motor run time limit.
(i) The Soft starter shall make it possible to run the motor in a weaker network and hence improving the availability of the system / equipment with following types.
i) Current.
ii) Dual current limit.
iii) Current ramp.
(j) Separate removable gland plates shall be provided for power and control cables. The gland plate for the power cables shall be of non-magnetic material.
(k) All sheet steel work shall be thoroughly cleaned of rust, scale, oil, grease, dirt and swarf by pickling, emulsion cleaning etc. The sheet steel shall be phosphate coated and then painted with two coats of zinc-rich primer paint. After application of the primer, two coats of finishing synthetic enamel paint oven baked/stoved, shall be applied.
(l) The cable alley shall house all power cable connections along with associated cable terminations.
(m) Each cubicle shall be fitted with a label in the front and rear of the cubicle, indicating the panel designation, rating and duty. Each relay, instrument, switch, fuse and other devices shall be provided with separate labels.
(n) A caution name plate with the inscription “Caution - Live Terminals” shall be provided at all points where the terminals are likely to remain live, and isolation shall be possible only at the remote end, e.g., incoming terminals of the main disconnecting switch.
(o) Starting of motor shall be from either the Soft Starter panel located near the motor or from the MCC Panel or from the PLC. Necessary wiring diagram shall be provided considering the starting interlock, trip circuit, and starting and running mode signal.

(p) The soft starter panel shall have soft start and soft stop facility during normal operation. Thyristor fuses shall have a trip indicator to operate a suitable micro switch with least 1NO + 1 NC potential free contacts for annunciation and / or tripping.

(q) The soft starter panel shall be installed in Air Condition room, it shall not club with PCC / MCC panels.
The soft starter panel shall be provided with sufficient ventilation for each unit. Necessary exhaust fan, louvers with filters must be provided in the cubicle to ensure proper ventilation

6.7.3 Main Busbars

(a) Busbars shall be supported on insulators capable of withstanding dynamic stresses due to short circuit.

(b) Busbars shall be of copper conductor of hard-drawn (HD) and high conductivity. All busbars shall be insulated with a close-fitting sleeve of hard, smooth, dust and dirt-free, heat-shrunk PVC insulation of high dielectric strength, to provide a permanent, non-ageing, and non-tracking protection, impervious to water, tropical conditions, and fungi.

(c) The temperature rise of bus bars shall be limited to 40 degrees centigrade over 45 degrees centigrade ambient temperature.

(d) All sheet steel work shall be phosphate coated in accordance with the following procedure and in accordance with IS: 6005 “Code of Practice for Phosphate coated Iron and Steel”. Oil, grease, dirt and swarf shall be thoroughly removed by emulsion cleaning. Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.

After phosphate coating, thorough rinsing shall be performed with clean water, followed by a final rinse with a dilute dichromate solution and even drying. The phosphate coating shall be followed by the application of two coats of ready mixed stoving-type zinc chromate primer. The first coat may be “flash dried” while the second coat shall be stoved. After application of the two coats of primer, finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied after completion of tests.

The final finished thickness of paint film on steel shall not be less than 80 microns and shall not be more than 120 microns. Finished painted surface of panels shall present an aesthetically pleasing appearance free from dents and uneven surface. A small quantity of finishing paint shall be supplied for minor touching up required at site after the installation of the panels.

6.7.4 Earthing

(a) An earthing bus shall be provided at the bottom and extended throughout the length of the panel. It shall be bolted/welded to the framework.

(b) All non-current-carrying metalwork of the panel shall be effectively bonded to the earth bus. Hinged doors shall be earthed through flexible earthing braid.

6.7.5 Panel Accessories and Wiring

(a) Panel shall be supplied completely wired internally up to equipment and terminal blocks and ready for the external cable connections at the terminal blocks. Inter-panel wiring shall be provided between the compartments of the same panel.

(b) All auxiliary wiring shall be carried out with 1100 volts grade, single core, stranded copper conductor with PVC insulation. The sizes of wire shall be not less than 1.5 sq. mm.

(c) Terminal blocks shall be of the stud type, rated for 1100 volts and 10 amps, complete with insulated barriers. Terminal blocks for CTs shall be provided with test links and isolating facilities.
(d) All spare contacts and terminals of cubicle-mounted equipment and devices shall be wired to terminal blocks.
(e) The accuracy class for indicating instruments (MFM with RS-485 communication port) shall be 1.0. Instruments shall be 110 mm / 96 mm square, with a 240 scale for flush mounting, where only the flanges project.
(f) Relays shall be suitable for flush mounting with only flanges projecting.
(g) Push buttons shall be provided with inscription plates engraved with their functions.
(h) Indicating lamps shall be of LED type.
(i) Space heaters of adequate capacity shall be provided inside each panel. They shall be suitable for a 240V, single-phase, 50Hz supply. They shall be complete with MCBs, isolating switches, and a thermostat.
(j) Each panel shall be provided with 240 Volts, 1 phase, 50Hz, 5 amps, 3-pin receptacles with a switch located in a convenient position. An interior illuminating CFL / LED lamp together with the operating door switch and protective fuses shall be provided.
(k) Provision shall be made for receiving, distributing, isolating, and fusing auxiliary supplies for controls, space heating, and other purposes. The fuse ratings shall be selected to ensure the selective clearance of sub-circuit faults.
(l) Fuses shall be HRC cartridge type mounted on a plug-in type fuse base.
(m) The auxiliary supply shall be distributed within the panel, with necessary isolating arrangements at the point of entry, and with sub-circuit fuses as required.

6.7.6 Cable Termination

(a) Necessary number of cable glands shall be supplied for terminating auxiliary power and control cables. Glands shall be of heavy-duty brass castings, machine finished and complete with check nut, washers, neoprene compression ring etc.
(b) Cable lugs for all power and control cable connections shall be supplied. The lugs shall be tinned copper/aluminium depending on cable conductor and of solderless crimping type.
(c) All necessary materials required for terminating the power cables such as tapes, fillers, binding wires, armour clamps, brass glands etc. shall be supplied.

6.7.7 Drawings and Data

All Drawings, data, technical, particulars, temperature rise calculations, detailed literature, catalogues, test certificates etc., shall be submitted along with the bid / after award of contract as specified under "Bid / Contract Drawings", Part 3, General Requirements, Volume - 2 of Bid Documents.

6.8 Diesel Standby Generator

6.8. 1 Applicable Standards

The Diesel Standby Generator (as per latest CPCB IV / KSPCB norms) and its components shall conform to the latest applicable standards specified below:

Diesel Engines for General Purposes	:	BS 5514 / ISO 3046
The Electrical Performance of Rotating Electrical Machinery	:	BS 5000
Rotating Electrical Machines	:	IS 15999-1

Circuit breakers	:	IS-13118, BS-5311, IEC-56 & 694, BSEN-60942 (P-2)
Air break switches	:	IS/IEC 60947-3, IEC 60947-3
Current transformer	:	IS 16227 (Part 2) : 2016/IEC 61869-2 : 2012/ BS-7626, IEC-60185
Potential (Voltage) transformer	:	IEC 60189
Electrical Relays	:	IS/IEC-60255, IEC-60255
Contactors/Starters	:	IS/IEC 60947-4, IEC 60947-4
Control Switches/Push Buttons	:	IS/IEC 60947-5-1, IEC 60947-5-1
High Voltage Fuse	:	IS 9385 (Part 1): 2018 IEC 60282-1:2009
Low Voltage Fuse	:	IS/IEC 60269-1: 2014
Indicating Instruments	:	IS-1248 / IEC-60051
A.C. electricity meters	:	IS 11448 / IEC 62053
Resistance wire, tapes and stripes for heating elements	:	IS-3725
Wrought aluminum and aluminum alloy bars, rods, tubes and sections for electrical purposes	:	IS-5082/IEC 60114
Specification for copper rods and bars for electrical purposes	:	IS-613
Toggle switches	:	IS-3452 / BS-3676
Control switches/push buttons Noise and Emission Limit	: :	IS/IEC 60947 / BSEN 60947 As per latest notification of ministry of Environment and Forests

6.8. 2 General Requirements

The diesel engine and generator shall be skid-mounted and located in a room adjacent to the treatment plant substation building. The diesel engine shall draw cooling air directly from outside the room through a weatherproof, acoustically treated duct. The exhaust system shall be insulated to minimize the amount of heat entering the room and to prevent injury to personnel.

The exhaust system pipe shall be required to be at a height above the nearest building as per the latest CPCB guideline. The exhaust pipeline diameter shall be suitably designed to avoid back pressure when discharged at a higher elevation. The silencer shall be of the 'residential' type and be located externally.

The generation voltage shall be 415V for D.G. capacity less than 2 MVA and 11 kV for D.G. capacity greater than 2 MVA. If more than one D.G set shall be required for achieving the required load capacity, they shall be operated in parallel with a necessary synchronizing arrangement with LCD. At no point shall D.G sets be operating in parallel with the grid.

6.8. 3 Tank

The tank shall be equipped with fittings to permit visual observation of the fuel level and to facilitate filling by local tanker operators. Level sensor/switches shall also be mounted in the tank, allowing the remaining fuel volume to be monitored at the generator/substation PLC and the operator stations in the SCADA room.

6.8. 4 Fuel system

The fuel System shall comprise an engine-driven feed pump with duplex filters, a high-level 990-liter day tank located in the generator room or a generator skid-mounted day fuel tank with supporting structure, or a generator skid-mounted day fuel tank, with all interconnecting pipe work, flexible engine connection pipe, etc. A semi-rotary hand pump shall be provided to permit transfer of fuel in the event of a failure of the transfer pump. Any leakage from the pumps shall be routed to the bund.

A fire alarm system shall be provided within the generator room to detect fire, to raise a local audible alarm (manually silenced locally).

All alarms shall be conveyed to the central SCADA through the PLC.

Diesel Generating Set Automatic Control
AMF Diesel Generator Set capable of automatic starting and picking the load within 30 seconds of power failure. Diesel generating set for use in auto mains failure mode shall have a three-position automatic / off / manual selection and shall operate as follows:

(i) Automatic mode:
On occurrence of mains failure, the following sequence shall be followed:

(a) Mains to Generator changeover.
- mains failure detected.
- delay of 10 seconds.
- generator shall be started and run up to speed.
- time delay of 50 seconds.
- mains supply shall be switched off.
- generator supply shall be switched on.

(b) Generator to Mains changeover.
- mains restored and healthy detected.
- manual changeover signal received.
- generator supply shall be switched off.
- mains supply shall be switched on.
- generator runs for 2 minutes and stops.

All timer settings shall be adjustable.

If mains power shall be restored during the initial one-minute delay then the power shall be monitored for a further one minute and if it shall be still healthy, mains power shall be restored. The generator shall be stopped after a further 2 minutes of running on no load. If the generator fails to start after an initial period of cranking, two further attempts shall be made with an appropriate interval between each attempt. If the engine fails to start after three attempts the system shall shut down and a local and remote alarm shall be annunciated.

(ii) Manual mode:
The generator shall run to the dictates of manual controls on the generator. No automatic changeover of mains to generator supply or vice versa shall take place. The generator shall be loaded by manual switching if required.

6.8. 5 Alternator for Diesel Generating Set

The generation voltage shall be 415V for capacity less than 2MVA and 11kV for capacity 2MVA and above.

Alternator shall be 4 pole, 3 phase, 50 Hz, 0.8 P. F, salient pole, revolving field, Brush less type, self-regulating continuously rated and manufactured in accordance with IS 15999-1, BS 5000: Part 99 or

IEC 60034-1. They shall be enclosed, screen-protected, fan-ventilated, and vertical drip-proof, conforming to IP 23.

The Alternator shall be complete with excitation system, AVR and all necessary auxiliaries. The alternator shall be driven by diesel engine detailed below and shall match the same in all respects. The terminal box shall be dustproof with IP54 degree of protection. The terminal box shall be suitably sized to terminate the size and number of cables involved. Alternators shall be capable of withstanding a 10% overload for 1 hour in any 12-hour period under the specified conditions of temperature, humidity, and atmospheric pressure.

Alternator windings shall be of Class H insulation with Class F temperature rise and tropicalised. The alternator shall have pre-packed grease lubricated ball or roller bearings and provided with facilities for degreasing whilst in service. The alternator shall be foot-mounted on a common bed frame with the prime mover close-coupled to the engine flywheel housing. The direction of alternator rotation when viewed from the driven end shall be clockwise and phase voltage sequence UVW. The alternator vibration level shall not exceed the values specified in IS 12075/IEC 60034-14. The alternator shall be capable of maintaining a short-circuit current of three times the full-load current for a period of 10 seconds.

The alternator shall be fitted with an anti-condensation Alternator shall have 6 nos. duplex RTDs inside the stator winding. No individual harmonic shall exceed 1% and the total harmonic shall not exceed 3%. The alternator, it's neutral and control panel shall be earthed as per relevant standards. Alternator rotor assembly shall comprise exciter rotor, full wave silicon bridge rectifier, surge protection device and salient pole rotating field system.

The rotor shall be fitted with interconnected pole face damping windings. Voltage regulation shall be maintained within ±2.5 % for a power factor of 0.8 to unity, including hot-to-cold variations. The steady-state frequency drop between no-load and full-load conditions shall not exceed 5%. Transient voltage deviation following a step load of 60% of the rated value at a power factor of between 0.4 and zero shall not exceed 15%. The voltage recovery time to 97% of the rated voltage shall not exceed 0.5 seconds.

The set shall be capable of continuous operation with a phase current imbalance of up to 33% of the rated current, while maintaining the output voltage within ±5 % of the rated value. Alternator shall have sensors for alternator protection and shall be wired to control panel. The alternator shall be provided with class F insulation with temperature rise limited to that of class B insulation.

6.8. 6 Diesel Engine for Generating Set

Engine shall be four-stroke, direct injection, and turbocharged industrial machines. They shall be fitted with renewable wet cylinder liners if water-cooled and shall be directly coupled to the alternator and mounted on a common rigid steel bedplate. Engines shall be rated for continuous duty at site ambient conditions with an inherent O/L Capacity of 10% for 1 hour in any 12 hours. The engine shall be capable of running at full load for a minimum of 180 hours without requiring maintenance adjustments and 10,000 hours between major overhauls. The maximum operating speed shall be 1500 rpm. The range of manual adjustment shall not be less than ±5% of rated speed. The performance of engine governors under load conditions shall be

- Mechanical Governor of Class A2 (upto 200kVA ratings)
- Electronic Governor of Class A1 with actuator (above 200kVA rating)

in accordance with ISO 3046 / BS 5514. Governor shall be a self-contained unit capable of monitoring speed.

Engine governors shall be suitable for remote control load sharing between identical engine units. In addition to any electrical overspeed trips, there shall be a mechanical overspeed device which shall operate at 120% of the rated speed. Re-setting of the overspeed trip shall be possible by hand only. The steady-state output speed drop between no-load and full-load conditions shall not exceed 5%. The transient output speed deviation shall not exceed 10% for a step of 60%.

Engines shall be designed to run on fuel oil that complies with IS 1460:2025 or BS 2869. Engines shall be cooled by means of a water jacket, heavy-duty air blast radiator with integral radiator header tank, circulating pump, and engine-driven pusher-type fan. The fan shall draw air in from the vicinity of the engine block and discharge it through the radiator core. The radiator shall be mounted on the same bedplate as the engine and alternator on suitable vibration isolators and be arranged so that it shall be located directly behind automatic louvers set into the external wall of the engine room. A thermostatically operated by-pass valve shall be fitted in the cooling system to maintain an optimum operating temperature during starting and running conditions. Drain cocks shall be provided so that all the water can be drained from the system. A separate oil cooler shall be used for cooling the engine oil. A thermostatic by-pass valve shall be incorporated.

Engine lubrication shall be by a closed-circuit wet sump, forced feed system supplied by an engine driven pump fitted with pressure regulating and relief valves, sump suction filter and changeover renewable micro-felt full flow line filters. A hand-operated semi-rotary oil pump shall be installed to carry out initial priming or to fill or empty the sump as required. The sump shall be fitted with an easily accessible drain point. The oil shall be of the grade recommended by the engine manufacturer.

The starting system shall comprise 12 or 24V heavy-duty lead-acid batteries (positioned on a floor-mounted stand adjacent to the engine) connected by heavy-duty flexible butyl rubber cables. Batteries shall be sized to give six consecutive starts of the engine at 0°C. An engine driven alternator and charging system shall be provided. An automatic main energized battery charger shall be provided, with sufficient capacity to maintain the battery in a condition to fulfil the starting requirements.

Barring (hand turning) equipment shall be provided so that the engine can be manually rotated for maintenance purposes. It shall be arranged so that the normal starting of the engine is inhibited while the hand-turning equipment is connected.

Twin heavy-duty air intake filters in accordance with IS 3169 or BS 7226, suitable for operating in dust-laden atmospheres, shall be fitted. The filters shall be of the paper element with pre-cleaner type. Turbo charger filters shall be fitted. Breathers shall be fitted with washable filters which are easily accessible for maintenance.

Instrumentation shall be provided to monitor speed, oil pressure, oil temperature (sets larger than 250kVA), water temperature and battery charge current. The bedplate shall be of heavy-gauge steel construction, stress relieved and free from distortion. Engine shall be provided with sensors for engine protection and shall be wired to control panel.

Machined surfaces shall be incorporated for mountings and for levelling. Anti-vibration mountings shall be fitted between the bedplate and the floor to prevent vibrations being transmitted to the building. The mountings shall be adjustable for levelling purpose and shall be designed to resist horizontal movement of the diesel set.

The fuel system shall comprise an engine-driven feed pump with duplex filters, a 990-liter day tank with supporting structures, or a generator skid-mounted day fuel tank with all interconnecting pipe work, flexible engine connection pipe, etc.

6.8. 7 Diesel Generator Control Panel:

The control panel shall have provisions for interoperability with the instrumentation control system. The control panel with communication facility shall be separately mounted on anti-vibration mountings and shall comprise the following:

- Breaker incorporating short circuit and overload trip.
- Earth fault protection for the Alternator.
- Alternator Over & Under Voltage Protection.
- Voltage Controlled Over Current Relay.
- Voltmeter with built in selector switch /(digital)
- ammeter with built in selector switch / (digital)
- frequency meter
- Power Factor Meter
- KWh Meter (Multifunction meter)
- Engine temperature and oil pressure gauge
- service hours run indicator
- key switch starts and stop control
- operational status indicator
- anti-condensation heater and thermostat
- alternator anti-condensation heater controls
- mains fed battery charger
- Auto start on mains power supply failure facility
- Fails to Start (Alarm)
- Over / Under Voltage (Alarm)
- Battery Charger Fault (Alarm)
- Low fuel Oil Level (Alarm)
- Overload (Alarm)
- Low Lube Oil Pressure (Trip)
- High Water Temperature (Trip)
- High Lube Oil Temperature (Trip)
- Electrical Protection Relays (Trip).

A reset button shall be provided to cancel the alarm / shut-down condition prior to re-starting.

Simple operating instructions shall be detailed on the fascia of the control panel. All alarm and trip status signals from diesel supply system, engine control panel and alternator protection shall be hard wired to a marshalling box for instrumentation control system.

Busbars shall be of copper conductor of hand drawn (HD) and high conductivity. All bus bars shall be insulated with close fitting sleeve of hard, smooth, dust and dirt free, heat shrunk PVC insulation of high dielectric strength, to provide a permanent non-ageing and non-tracking protection, impervious to water, tropical conditions and fungi.

6.8. 8 Synchronising Panel

Whenever two or more sets are required to operate together, necessary synchronizing panel complete with circuit breaker, synchro scope, numeric relays, digital meters etc shall be provided. The Panel shall be floor standing, CRCA Sheet steel enclosed.

6.8. 9 Acoustic Enclosure

(i) The DG Set shall be provided with acoustic enclosure, fully integrated, weatherproof with superior finish for long and durable life.
(ii) The acoustic enclosure shall be CRCA sheet steel enclosed with necessary panels and doors, inside lining of fire-retardant foam / glass wool as acoustic material.
(iii) Stiffeners shall be provided wherever necessary to strengthen the door and side covers.
(iv) The sound level shall be restricted to 75dB at a distance of 1 meter, under full load, free field conditions as per relevant standards.
(v) The acoustic enclosure shall be certified to meet the emission norms.

6.8. 10 Drawings and Data

All Drawings, data, technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates of typical transformer etc shall be submitted along with the bid / after award of contract as specified under "Bid / Contract Drawings", Part 3, General Requirements, Volume - 2 of Bid Documents.

6.9 UPS, Battery, Battery Charger and D.C Distribution Board

UPS shall be supplied as per Instrumentation specification, Volume 2/Part 7. UPS, Battery, Battery Charger shall be three phase incoming supply with breaker. DC equipment shall comply with IEC 60896 including those standards referred to therein.

6.9.1 General Requirements

Following items shall be covered in the Contract:

- One no. 110V Nickel Cadmium type Battery Bank (sized as per requirements mentioned in Part 12).
- One no. Float-cum-boost charger for 110V batteries.
- DC distribution board.

All connections between battery, battery chargers and DC distribution board shall be designed for effective segregation between positive and negative leads.

<u>Battery Room Layout Requirements:</u>

- Battery cells shall be installed in a separate room, preferably near the DC loads.
- Light fixtures in the battery room shall be flameproof and shall preferably mounted on walls, or if installed on ceiling shall not mounted directly above the battery banks. Switch controls for lights and exhaust fans shall be installed outside the battery room.
- False ceiling & false flooring shall be avoided in the battery room. Ducts or other systems shall not be run through battery room.
- 2 Nos. Flameproof exhaust fans shall be provided to exhaust gases and smoke from the battery room (in case of fire from the battery room).

- Battery room up to 2 mtrs height shall be provided with acid-proof tiles. Wall above 2 mtrs and roof beams shall be painted with alkali-resistant protective coating.

- A wash basin with an eye washer shower shall be provided in the battery room.

- A warning sign board should be displayed at the entrance and inside the battery rooms in view of the presence of Hydrogen gas. A hydrogen gas detector shall be installed based on vendor recommendations.

6.9.2 Nickel-Cadmium Battery

Design Features

(a) Battery offered shall be Nickel Cadmium (Ni-Cd), Sintered Type. The battery shall conform to the latest applicable standards specified below:

Specification for sintered type : IS 10918
Nickel Cadmium Sintered Batteries

(b) Nickel hydroxide and Cadmium hydroxide shall be used for positive and negative electrode respectively. An aqueous solution of battery-grade Potassium hydroxide with small quantities of lithium hydroxide shall be used as electrolyte. It shall be used only for ion transfer and shall not chemically change during charging/discharging.

(c) The containers shall be transparent and preferably be made of toughened glass or plastic polypropylene material and provided with electrolyte level indicator. The Containers shall be robust, heat resistant, leak-proof, non-absorbent, and free from cracks, blisters, pin holes, etc.

(d) The battery shall be rated on 5-hour basis and for the specified ambient temperature. The battery shall have a maximum recharge time of 8 hours.

(e) Terminal posts shall be designed to accommodate external bolted connections conveniently and positively. Each terminal post shall have two bolt holes of the same diameter, preferably at right angles to each other. The bottom hole shall be used to terminate the inter-cell connection. The top hole shall be left for external terminal connections. Bolts, heads, and nuts, except seal nuts, shall be hexagonal and shall be lead-covered. The junction between terminal posts and cover and between cover and container shall be so sealed as to prevent any seepage of electrolyte.

(f) Required quantity of electrolyte for first filling with 10% extra shall be supplied in non-returnable containers.

(g) Each battery shall be complete with following accessories, as applicable, that include, but are not limited to:

(i) Battery racks.

(ii) Porcelain insulators, rubber pads, etc.

(iii) Set of inter-cell, inter-tier and inter-bank nickel coated copper connectors as required for the complete installation.

(iv) Electrolyte for first filling + 10% extra.

1 set of accessories for testing and maintenance shall also be provided suitable for all the three battery banks.

i.	One	-	-3, 0, +3 volts DC voltmeter with built-in discharging resistor and suitable leads for measuring cell voltage.
ii.	One	-	Filler hole float fitted with plug and cap and having specific gravity correction scale.
iii.	Three	-	Digital portable Pocket thermometers.
iv	Two	-	Cell lifting straps.

v	One set - Each of		Terminals and cable boxes with glands for connecting cable as required. Spare connectors. Spare vent plugs. Spare nuts and bolts. Suitable set of spanners.

(h) Each battery shall be mounted in a manner that permits easy accessibility to any cell. The racks shall be suitable for fixing on flat concrete floor. The complete racks shall be suitable for bolting end to end.

(i) It shall be the responsibility of the contractor to provide batteries of adequate capacities to meet specified requirements pertaining to control, indication, annunciation, etc. and emergency lighting. For computing battery capacity, it shall be assumed that the battery is fully charged at the beginning of loading cycle and is discharged to a voltage of 1.2 volts per cell at the end of the loading cycle. The battery shall have minimal difference (approx. 0.3 V per cell) between float and boost charging voltages.

(j) The following information shall be legibly marked on the outside of each cell.

- Manufacturer's Name & Trademark.
- Country & Year of Manufacture.
- AH Capacity at 5-hour discharge rate.
- Type Designation & Sl. No.

6.9.3 Drawing

All Drawings, data, technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates of typical transformer etc shall be submitted along with the bid / after award of contract as specified under "Bid / Contract Drawings", Part 3, General Requirements, Volume - 2 of Bid Documents.

6.9.4 Battery Charger and D.C. Distribution Board

Applicable Standards

The battery charger and D.C. distribution board shall conform to the latest applicable standards specified below. In case of conflict between the standards and this Specification, this Specification shall govern.

Basic climatic and mechanical durability tests for components for electronic and electrical equipment	:	IS/IEC 60068
Environmental tests for electronic and Electrical equipment	:	IS/IEC 60068
Metal clad base material for printed circuits for use in electronic and telecommunication equipment	:	IS:5921
Transformers and inductors (power, audio, pulse and switching) for electronic equipment	:	IS:6297
Printed wiring boards	:	IS:7405
Environmental requirements for semi-Conductor devices and integrated circuits	:	IS 6553
Terminals for electronic equipment	:	IS:4007

Factory built assemblies of switchgear and control gear for voltages up to and including 1000V AC and 1200V DC	:	IS/IEC 61439 / BS: 5486 / IEC:61439
Air break switches	:	IS/IEC: 60947 BSEN 60947-3
Miniature circuit breakers	:	IS 8828 / BSEN:60898
HRC cartridge fuses	:	IS:9224/BS:88
Contactors	:	IS/IEC:60947 / BS:775 / IEC:60158 - 1
Control switches/push buttons	:	IS:6875
Indicating instruments	:	IS:1248 / BC:89 / EC:51
Degree of Protection	:	IS/IEC:60947 / IEC:60947 - 1
Climate-proofing of electrical equipment	:	BSCP:1014
Code of practice for phosphate coated iron and Steel	:	IS:6005 / BS:3189
Semi-conductor converters	:	IEC:60146
Semi-conductor rectifier equipment safety code	:	IS:6619
Specification for copper rods and bars for electrical purposes	:	IS: 613

6.9.5 Battery charger

(a) Battery charger shall be combined float-cum-boost type.

(b) The charger shall be static type composed of silicon-controlled rectifiers (SCRs) and diodes connected in three phase full wave half-controlled bridge circuit.

(c) The rectifier transformers for float and boost chargers shall be indoor dry type, double wound with delta-star connections. The BIDDER shall ascertain if taps are required and provide adequate number of primary and secondary taps, if necessary.

(d) The float charger shall be designed for supplying:

(i) The D.C continuous load and short-time overload.

(ii) The trickle charging current of the battery.

(e) The boost charger shall be designed for supplying the boost charging current of the battery.

(f) If the battery and charger are to be supplied by separate contractors, the charger contractor shall coordinate with the battery contractor regarding float / trickle boost charging current & voltages required for the battery.

(g) Battery Charger shall be provided with facility for both automatic and manual control of output voltage and current and necessary selector switch shall be provided. contractor regarding the float / trickle and boost charging current and voltages required by the battery.

(h) Performance

(i) Float Charger

The D.C. output voltage during float charging shall be stabilized within ± 1% of the set DC bus voltage. Manual control shall be used if auto mode fails.

(ii) Boost Charger

For boost charging the discharged battery after a mains failure, the rectifier shall charge the battery at high rate limited to the maximum boost charging voltage. After a specified number of hours (adjustable) when the rated cell voltage shall be reached, the charger shall be returned to float charge status.

- In case of combined float cum boost charger, the switching and control of high-rate charge and return to float charge shall be by automatic controller / regulator. Manual control shall be used if auto-mode fails.
- During boost charging following emergency measures shall be provided:

- If the AC mains supply fails, an arrangement shall be made to automatically connect the battery directly across the load.
- If the separate or spare float charger supplying D.C. load fails, the load shall be fed from the point of connection at the tapping of the battery via adequately rated blocking diodes.

(iii) Suitable filter Circuits shall be provided in the chargers to limit the ripple content (peak to peak) in the output voltage to 1% irrespective of D.C Loads.

(i) The D.C System shall be unearthed. sensitive earth fault detectors shall be provided in D.C system to annunciate earth fault.

(j) Special digital ammeter with zero centre for status of battery charging and discharging.

(k) All other meters shall be digital type only.

6.9.6 Charger Panel and D.C. Distribution Board

(a) Battery charger panel and D.C. distribution board shall be sheet metal enclosure free standing type with cable entry from top.

(b) Indications, controls and output voltage setting adjustments shall be on front panel. The contractor shall submit a scheme for alarm and trip indication lamps on the cabinet and for fault annunciation contacts paralleled for remote annunciation.

(c) The components shall be liberally rated and housed in a well-ventilated sheet metal cubicle complete with input and output terminals. Louvers shall be provided for ventilation backed up by fine wire mesh so that the degree of protection shall be equal to or better than IP-42.

(e) Busbars shall be of Electrolytic copper Grade conductor of hard drawn (HD) and high conductivity. All busbars shall be insulated with a close-fitting sleeve of hard, smooth, dust and dirt-free, heat-shrunk PVC insulation of high dielectric strength, to provide a permanent, non-ageing, and non-tracking protection, impervious to water, tropical conditions, and fungi.

(d) All printed circuit cards shall be plug-in type, interlocked to prevent insertion in the wrong slot. Each card shall have an LED indication on its front plate to indicate normal condition and readily marked test pins.

(e) Stiffeners shall be provided wherever necessary to strengthen the door and side covers.

(f) All components shall be accessible to the maintenance technician for easy disassembly and replacement. Access to parts of equipment shall be with minimum danger from all hazards.

(g) All components and modules shall be clearly and unambiguously marked, and all wiring shall be colour-coded and tagged.

(h) All power and control wiring within the cubicle shall be done with stranded copper wires. The power wiring shall be adequately sized for the required rating. The minimum sizes for control wiring shall be 1.5 sq mm and for power wiring shall be 2.5 sq mm, 650 / 1100V grade.

(i) Ground terminals with isolating links shall be provided.

(j) Cable glands shall be provided to suit the incoming and outgoing cables.

(k) DC DB shall meet the emergency lighting requirement also.

6.9.7 Components / Accessories

(i) The main items are listed below. However, additional items required for completeness or to meet the specified performance or operational requirements of the charger, shall be deemed to be included in the contractor's scope. Instead of incoming ON / OFF switches, sticker fuses, and contactors, the contractor may provide suitably rated 3-pole MCBs with overload and short circuit protection and auxiliary contacts.

(ii) One (1) set - Three-phase full-wave half-controlled bridge rectifier circuit comprising silicon-controlled rectifiers and silicon diodes, complete with resistor / capacitor network for surge protection. The diodes / SCRs shall be individually protected by fuses with fuse fail indication.

(iii) One (1) Double wound, dry type, three phases suitably rated mains transformer.

(iv) One (1) set of suitably rated control transformers for electronic controller.

(v) One (1) Electronic controller comprising of power supply card, soft start cum current limit card, auto trickle mode card with facility for setting trickle charge current and monitoring battery current, error amplifier cards and pulse generating cards for achieving the DC output voltage stabilisation of ± 1% and also for achieving current limiting feature. The electronic controller shall have protection features with indications for under-voltage, over-voltage, set output voltage and phase failure or voltage unbalance.

The electronic controller shall be provided with following features.

- Boost current stabilization of ± 2% with AC input variation of voltage and frequency variation of ± 10% and ± 5%, respectively.
- Boost charge current limiter with potentiometer to adjust the setting.

(vi) Adequately sized necessary built-in accessories shall be provided such that on failure of the controller in auto mode the voltage can be effectively controlled manually.

(vii) One (1) Filter circuit comprising of smoothing choke and condensers complete with HRC fuse with trip indication for filter condenser circuit.

(viii) One (1) Auto / Off / Manual selector switch for selecting the mode of operation of the controller.

(ix) One (1) front panel mounted potentiometer for set point adjustment of output voltage in auto mode.

(x) One (1) front panel mounted potentiometer for manual adjustment of voltage in manual mode.

(xi) One (1) TP AC ON / OFF switch for float charger incoming.

(xii) One (1) set of MCB / HRC fuses complete with fittings for AC input with suitable ratings and trip indication.

(xiii) One (1) set of the pilot lamps with series resistors to indicate float charger AC Mains 'ON' condition.

(xiv) One (1) Digital voltmeter, ammeter and frequency meter for Mains.

(xv) One (1) AC contactor with suitably rated coil and three main and 2 NO + 2 NC auxiliary contacts, suitably rated thermal overload relay and ON / OFF control switch.

(xvi) One (1) set of HRC fuses complete with fuse fittings for the DC output, and with trip indication.

(xvii) One (1) moving coil DC ammeter, with shunt, of size 96 x 96 mm and suitable range to read the float charger output current.

(xviii) One (1) moving coil DC ammeter, with shunt, of size 96 x 96 mm and suitable range to read the charging and discharging current for battery.

(xix) One (1) Double pole DC ON / OFF MCB switch for float charger output.

(xx) One (1) pilot lamp with series resistor to indicate float charger DC 'ON' condition.

(xxi) Annunciation System with communication facility for the following

- AC Supply Failure.
- Rectifier Fuse Failure.
- Surge Circuit Fuse Failure.
- Filter Fuse Failure.
- Load Limiter Operated.
- Charger Trip.
- Battery on Float.
- Battery on Boost.

6.9.8 Power Electronic Components

(a) Diode and thyristors shall be of monocrystalline type silicon, capable of continuous output at specified voltages. It shall have high power efficiency.

(b) If any diode or thyristor assemblies are connected in parallel, care shall be taken to ensure that each rectifier or thyristor operates within its rating and shares the load uniformly. This may be achieved with the help of chokes. Also, care should be taken to select matched pairs of rectifier heat sink units.

(c) Each diode or thyristor built in a multi-built assembly shall be provided with a short circuit protection to avoid complete shut-down of the equipment because of a fault on single unit. Suitable fuses shall be provided for such protection.

(d) Necessary spare capacity shall be built in the equipment to continuously supply full load even with one unit out of circuit.

(e) The diodes or thyristor banks shall be natural air cooled.

(f) The diodes or thyristors shall be protected against overvoltage due to chopping surges with the aid of snubbers (i.e., resistor-capacitor combination and Metal oxide varistor). It shall be ensured that normal load currents and especially fault currents are shared equally between parallel links, within the specified limits. To achieve this, great care shall be taken to design the layout of the rectifier links to ensure equal lengths of busbars and as near as possible identical contact resistance in each current path.

6.9.9 Drawings and Data

All Drawings, data, technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates of typical transformer etc shall be submitted along with the bid / after award of contract as specified under “Bid / Contract Drawings”, Part 3, General Requirements, Volume - 2 of Bid Documents.

6.10 Variable Frequency Drives

The Variable Frequency system shall have a provision such that interoperability with the instrumentation control system for flow control.

6.10.1 Applicable Standards

(a)	Specification for metal clad base materials for printed circuits for use in electronic and telecommunication equipment	IS:5921
(b)	Specification of Transformers and Inductors (Power, Audio, Pulse and Switching) for Electronic Equipment	IS:6297
(c)	Semiconductor rectifier equipment safety code for	IS:6619
(d)	Specification for printed wiring Board	IS:7405
(e)	Recommended practice for emergency and stand by power systems for industrial and commercial application.	IEEE:446
(f)	Semiconductor devices	IS:3700
(g)	Basic climate for mechanical durability tests for electronic components	IS:9000
(h)	Environmental requirements of semiconductor devices and integrated circuits	IS:6553
(i)	Ambient temp. of electronic Equipment	IS:9676
(j)	Terminal for electronic equipment	IS:4007

6.10.2 Configuration

All VFD's shall be ultra-low Harmonic and shall have one of the two configurations given below Suitable for induction motor protection of all types confirming to IS 12615 / IEC 60034 / IS/IEC 60947 / IEC 947

(a) Current source inverter.
(b) Voltage source inverter.

6.10.3 Converter

The Converter shall be of full wave rectifier type with minimum number of pulses 6 or more Smoothing Reactors for Current and Voltage Source Inverter.

(a) The smoothing reactor shall be sized to avoid conditions of discontinuous current
(b) Drives shall have ultra-low harmonic drive (ULH) to reduce harmonic reduction to less than 5% THD_i (total harmonic distortion-current and voltage). Modern, compact, all-in-one solution that ensures harmonics are mitigated at source at all loads when connected to either a mains or generator supply.
(c) Operation of the frequency converter at its lowest frequency of operation, which shall not be less than 5 Hz.
(d) The smoothing reactor shall be uniformly insulated and shall be protected for voltage surges occurring during sudden load throw-off.
(e) The smoothing reactor shall be made from electrolytic grade copper and shall be epoxy encapsulated with suitable class of resin decided from techno-economic considerations and performance requirements in conformity with IEC-146.
(f) Drives shall have cooling fans for additional energy saving during partial load situations.
(g) Semiconductor fuse shall be provided for protection of drive.
(h) Drives shall have built-in EMC filters suitable for network connection as standard.
(i) Drives shall have following features:
(i) Level control.
(ii) Pump cleaning.
(iii) Intelligent multi-pump control.
(iv) Flow calculation.
(v) Pump protection.
(vi) Quick ramps.
(vii) Turbidity reduction.
(viii) Communications loss backup mode.
(ix) EMC compliance.
(x) Modbus protocol.
(xi) Safe torque off.

6.10.4 Inverter

The inverter system suitable for three phase output shall consist of the following subsystems:
The basic inverter circuit consists of the switching device, such as Thyristors / Transistors / IGBT / MOSFET, connected so as to supply three-phase power.

(a) The logic network enables the rapid transition of the main inverter switching devices from the on-state to the off-state.
(b) A suitable feedback system to allow the balance of reactive power flow during load power factor fluctuation as well as regeneration.
(c) The filter system of the inverter output to suppress 5th, 7th, 11th, 13th harmonics at the output of the inverter to less than 5% of the fundamental amplitude.
(d) The ripple control system to limit current ripple to 4% at the input terminals of the inverter caused by distorted current output.

The output frequency of inverter shall be controlled to within the limits.

6.10.5 Inverter for AC drive

(i) Current Source Inverter

(a) Constant Torque Operation

The current output by the DC link shall be accurately monitored so that the ratio of the terminal voltage of the motor and the corresponding frequency remains constant. Necessary protective features for tripping the frequency converter, alarm/annunciation and fault diagnostics shall be provided.

(b) Constant Horsepower Operation

In this type of operation, the motor's internal voltage shall be maintained within + 1% while the frequency of the inverter shall be varied to meet the duty cycle requirements. Necessary protective features for tripping the frequency converter, alarm / annunciation and fault diagnostics shall be provided.

(ii) Voltage source Inverter

(a) Constant Torque Operation

The DC voltage input to the inverter shall be accurately monitored to maintain the ratio the terminal voltage of the motor to frequency at the rated / design value. The DC voltage input shall be maintained within + 1% of the required value. Should this fall for any reason, necessary action for tripping the frequency converter and initiation of annunciation/alarm and fault diagnostic shall be provided.

(b) Constant Horsepower Operation

In this type of operation, the voltage at the terminals of the motor shall be maintained within + 1% of the rated value while the frequency of the inverter shall be varied to meet the duty cycle requirements. Necessary protective features for tripping the frequency converter, initiation of alarm/annunciation and fault diagnostic shall be provided.

6.10.6 Output Over Current Limit

Unless otherwise stated, the inverter shall be capable of being temporarily overloaded to 150% of its full load ampere capacity for sixty (60) seconds beyond which a current limit action shall be initiated, and an alarm contact initiated for annunciation.

6.10.7 Control Modules

All elements of the control system shall be mounted on epoxy laminate boards and each board shall be a plug-in module mounted on a standard nineteen-inch rack which shall be accessible from the front. Each card shall have an LED indicator on its front plate to indicate the card's normal operating condition. Readily accessible and clearly marked test pins shall be provided at the important points on the cards to enable signal analysis.

The epoxy laminates shall be free from manufacturing errors and shall be designed to prevent incorrect insertion in the card rack. The copper side of the card shall be suitably lacquered to prevent oxidation. The gap between two cards shall be sufficient to permit adequate ventilation.

Adjustments susceptible to change by accidental contact shall be lockable.

6.10.8 Control Requirements

Short time voltage dips up to 80% of nominal (e.g., in case of large motor start-up connected to same bus) shall not cause the control system to stop functioning and shall not trip the drive system.

The drive motor shall be speed-regulated corresponding to a 4 - 20mA or 0 - 10V reference input signal. Upon complete loss of users speed reference signal, the drive shall automatically run at constant speed as determined by the last speed reference available prior to loss of the signal.

The required provision for interfacing with PLC / DCS, including details of the communication module and data transfer facility, I/O details shall be furnished by the Bidder.

6.10.9 Protection

Protection of Power Semiconductor

Each power semiconductor shall be protected against short circuit. The fuse shall be sized so that its I^2t does not exceed the I^2t characteristic of the power semiconductor itself. The voltage and current rating of the fuse shall match the duty on the power semiconductor. The arc voltage, due to melting of the fuse shall not exceed the repetitive peak reverse voltage of the power semiconductor.

Thyristor fuses shall have a trip indicator that operates a suitable microswitch with at least one NO and one NC potential-free contact for annunciation and/or tripping.

A fast-tripping feeder circuit breaker shall be used in cases where fuses for short-circuit protection of thyristors are not used.

Protective Systems for AC Inverter Drive

Fuses for all power semiconductors and / or other devices like commutation chokes, capacitors etc. which are not adequately protected against flow of abnormal currents.

Under-voltage and over-voltage protection on the input side. Loss of input voltage to inverter shall entail tripping of the inverter.

Protection for all control cards, power supply stabilizers, filter circuits etc. Protection shall be provided such that failure of a part does not cause damage elsewhere in the system.

- Polarizing relay to prevent reversal of polarity on the input side of the inverter.
- Protection of inverter thyristor, commutating circuits and other inverter elements during regenerative operation of the inverter and also during sudden load throw-off.
- Current limit fuses at the output of the inverter.
- Commutation circuit under voltage.
- Inverter over frequency.
- Programmable over current.
- Phase sequence / loss of phase protection.
- Earth fault protection.
- DC link overvoltage protection.
- Specific motor protection.
- Incoming line surge protection.
- Ventilation Loss.
- Over temperature.

6.10.10 Cooling of Power Converters

Power semiconductors shall be mounted on a heat sink, which can be individual or common to a number of devices. Adequate provision for clamping and mounting the power semiconductors shall be available.

Cooling of power semiconductors can either be natural air cooled or forced air cooled. The BIDDER shall recommend the type of cooling. However, for power converters that exceed capacities of 2 kA

continuous load, alternative cooling methods, such as oil or water cooling, shall be considered. The power semiconductors shall preferably be double-sided cooled.

6.10.11 Switching Devices

Switching devices such as circuit breakers, isolators, contactors; switch-fuse units etc shall be considered in the scope of supply.

The switching devices shall be enclosed in a separate enclosure forming the set of panels for the power converters. They shall have adequate clearance both with adjacent devices and metalwork at earth potential. Connection between devices shall be by adequate size of electrolytic grade of copper strips. These connections shall be adequately braced and insulated.

6.10.12 Constructional Features

The controller should have modular construction to facilitate maintenance.

The drive rating 22kW and above there is a separate (VFD panel) panel shall be provided and installed in Air Condition room, it shall not club with PCC / MCC panels. For protection semiconductor fuse shall be provided for Variable Frequency Drives (VFD).

Busbars

Power connections shall be of the bolted type and mating surfaces shall be tinned. The bus bars running to various converters shall be suitably designed to ensure equal sharing between the parallel strings and prevent mechanical stress on the fuse.

All bus bars shall be of Electrolytic copper Grade conductor of hard drawn (HD) and high conductivity All bus bars shall be insulated with close fitting sleeve of hard, smooth, dust and dirt free, heat shrunk PVC insulation of high dielectric strength, to provide a permanent non-ageing and non-tracking protection, impervious to water, tropical conditions and fungi.

All cubicles shall have copper earth buses of adequate size running the entire cubicle height along the sides.

Cubicle

Cubicles housing the power semiconductors and drive level control system shall conform to IP 42 degree of protection to enclosures.

Panels shall be free standing, floor mounting type and shall comprise rigid welded structural frames enclosed completely with cold rolled sheet steel of thickness no less than 2.5 mm for front and rear portions and 2.0 mm for sides, top and bottom portions. There shall be sufficient reinforcement to provide level surfaces, resistance to vibrations and rigidity during transportation and installation. Stiffeners shall be provided wherever necessary to strengthen the door and side covers.

All doors, removable covers and panels shall be gasketed all round with neoprene gaskets, exhaust fans, ventilating louvers shall have screens and filters to heat dissipation. The screens shall be made of either brass or GI wire mesh.

Design, material selection and workmanship shall be such as to result in a neat appearance inside and outside with no welds, rivets or belt heads apparent from outside, with all exterior surfaces true and smooth.

Painting

All sheet steel work shall be phosphate coated in accordance with the following procedure and in accordance with IS: 6005 "Code of Practice for Phosphate coated Iron and Steel" Oil, grease, dirt and swarf shall be thoroughly removed by emulsion cleaning Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.

After phosphate coating, thorough rinsing shall be with clean water, followed by final rinsing with dilute dichromate solution and even drying.

The phosphate coating shall be followed by the application of two coats of ready mixed stoving type zinc chromate primer. The first coat may be "flash dried" while the second coat shall be stoved.

After application of the two coats of primer finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied after completion of tests.

The final finished thickness of paint film on steel shall not be less than 80 microns and shall not be more than 100 microns.

Finished painted surface of panels shall present an aesthetically pleasing appearance free from dents and uneven surface.

A small quantity of finishing paint shall be supplied for minor touching up required at site after the installation of the panels.

6.10.13 Bins and Printed Circuit Cards

Individual bins shall be mounted on a swing able frame so that the connections at the rear are also accessible.

Self-retaining thumb head screws shall be needed for holding the bins in position. Adequate number of card / bin extenders for testing of PCBs shall be provided, each with flexible cables at least two meters long. These extenders shall be of a universal type suitable for use with any card / bin as the case may be.

All adjustments that are to be made while changing a card shall be outside in a separate module, preferably plugged into the regulator bin.

Locking of individual cards in a bin shall preferably be through self-retaining thumb-head screws. Control modules shall be in the form of plug-in packages, plugged into a module bin. Each plug-in unit shall consist of a strong frame on which a printed circuit board would be permanently screwed. The plug connections shall only be of the pin type.

The printed circuit board (PCB) shall be made of glass fibre filled with epoxy laminates. The plug-in unit shall be screwed to the basic socket in the module bin with long through bolts and knurled heads.

The front plates of the plug-in unit shall have the switches, the potentiometers, miniature monitoring meters, test points etc. Each plug-in unit shall have its own identification legend.

All plug-in units shall be polarized to prevent incorrect insertions into the module bin.

The gap between two plugs in units inside a bin shall be sufficient to permit adequate ventilation.

The copper side of the printed circuit board shall be lacquered to prevent oxidation. Each side of the printed circuit board shall have a shield cover to prevent inter circuit and external interference.

The PCB shall be mounted on PCB guides fixed on standard racks and the shield properly grounded. Control circuit test points shall be easily accessible for monitoring and maintenance.

6.10.14 Annunciation

The annunciate shall work on DC power supply with communication facility (RS 485 port) Fault and Trip shall be separately communicable with PLC. Each annunciate window shall have two LED lights connected in parallel which operate at not more than 75% of their rated voltage. Window shall be arranged in a logical group. The annunciate shall have a module construction with glass epoxy plug in cards.

Electronic hooter / Alarm bell / siren shall be continuously rated, The Annunciator shall have the following facilities:

(a) First in sequence, memory reset.
(b) faults shall be memorized.
(c) Test Feature.

There shall be a three-tier system of protection and annunciation:

(a) Alarm both audible and visual.
(b) Warning with delayed shut down time delay through a timer of range 0-60 sec.
(c) Disturbance associated with failures of systems elsewhere with serial communication port.

6.10.15 Meters

Individual meters shall be provided for speed reference, speed feedback, current reference, current feedback, pulse output, and regulated power supply voltages.

All meters shall be identical and fed through individual buffer IC amplifiers. All meters shall be the circular scale type having a full-scale deflection of 270deg. All meters shall conform to at least accuracy class 1.0

All meters with their individual buffer amplifier cards shall be housed in separate bin. It shall be recommended that the buffer amplifiers all be housed on a single / two cards and this card be itself / themselves housed in the regulator bin.

Sensitive signal leads in that case shall not have to traverse from one bin to another, only noise insensitive buffer amplifier output leads shall need to go to the meter bin. Selector switches if used with any meters shall have pistol grip handles.

6.10.16 Wiring

Stranded, flexible copper cable of 2.5 sq.mm shall be used for CT circuits and 1.5 sq.mm for other control circuits. However, for PCB terminals 0.75 sq.mm tinned copper wire may be accepted.

Ultra-flexible cables shall be used for all connections from a fixed part to a movable member. In addition, a hanging loop of sufficient length shall be provided to avoid any cable stressing.

All terminal boards for outgoing connections shall be at a height of at least 250 mm from the cubicle floor, and preferably tilted at an angle of 45^0 to the horizontal for ease of connections. Similarly, connection of the incoming power cables to the bus bars shall be done at a height of at least 250 mm from the cubicle floor.

Item designation and location marking shall be in line with IEC recommendations.

Device labelling shall be on its fixed mounting and not on the device itself such that labelling remains even when the device shall be replaced. Metallic labels / paper labels or sticker shall be accepted.

6.11 Non-Segregated Bus Duct

Bus duct shall be provided for all transformer/ DG ratings of 1000kVA and above.

6.11.1 Bus Enclosure

- The enclosure shall be made of aluminium alloy with minimum thickness of 3mm.
- Stiffeners shall be provided wherever necessary to strengthen the enclosure.
- Bus bar cross over shall be avoided and shall be suitably coordinated with transformer manufacturer and panel manufacturer by the contractor.
- Silica gel breather and space heater with thermostat shall be provided as required.
- The entire bus duct shall be designed for indoor / outdoor installation, with a dust and vermin-proof construction. Bus duct installations meant for outdoor application shall be of weatherproof construction and shall have degree of protection better than or equal to IP-55 Outdoor portion of bus duct shall be provided with rain hood.
- The inside of the bus enclosure shall be treated with a matt paint of dark colour, preferably black to facilitate efficient heat dissipation. The bare enclosure with above painting shall be designed so as not to exceed the temperature specified in IS:8084 and MS epoxy painted with outer shade of Epoxy paint of shade 631 of IS 5. Paint thickness shall be not less than 100 microns.
- Joints consisting of metallic expansion bellows shall be provided on the bus enclosure at following points:
  (i) At terminations at transformers.
  (ii) At terminations at switchgear cubicles.
  (iii) In the run of the bus duct in case of long lengths as required.
- Flexible expansion joints for the enclosure shall be provided wherever deemed necessary. The flexible joints shall take care of expansion and contraction due to temperature variations and fault conditions.
- Necessary bonding shall be provided at the above expansion joints if joints are made of insulating material.
- Three-phase terminal enclosures shall be provided with flanged ends with drilling dimensions to suit the flange at equipment terminals.
- The flanges shall be provided with gaskets, nuts, bolts etc.
- Provision shall be made for periodic inspection of insulators by means of inspection covers. The inspection covers shall be provided at the bottom with quick-acting stainless-steel clamps and shall have gaskets. There shall be no joints or fixing bolts on the top surface through which water could seep through.
- The drain plugs shall be easily removable for cleaning purposes.
- The gasket material and thickness shall be so selected as to satisfy the operating conditions imposed by temperature, weathering, durability etc. Care shall be exercised to ensure that covers fit easily, that the required compression of the gaskets can be obtained without damage to the inspection covers by bolts and that covers do not bend after this compression has been applied Over-compression of the gaskets shall be avoided.
- The material of the gasket shall preferably be neoprene closed-cell sponge rubber or equivalent.
- Flange gaskets shall be provided at the equipment terminal connections.
- The bus duct shall not have any through bolts. All nuts and bolts shall be mild steel hot dip galvanized GS spring washers shall be provided for making satisfactory joints Clamps, splice plates etc shall be provided wherever necessary.

- Whenever the outdoor portion of the bus duct shall be of flanged construction but of bolted type a continuous hood made of non-magnetic material shall be provided over the entire length of the outdoor portion of the bus duct to prevent ingress of water particles due to heavy rain fall directly on bus duct enclosure. This hood shall be mounted on bus duct supporting structures and all hardware and accessories required for mounting the hood shall be included in scope of supply.

6.11.2 Bus Conductor

- The material of the conductor shall be of EC grade aluminium alloy.
- The temperature rise of conductor shall be as per IS:8084. Also, the temperature of the bus shall not exceed 250°C while carrying the specified short circuit current for one second when a fault occurs at the operating temperature.
- The bus conductor shall be given a coat of matt black paint to facilitate heat dissipation. The bare conductor with above painting shall be designed to carry the normal rated current without exceeding temperature rise as specified in IS:8084.
- Bus bars shall be colour coded with colour PVC tape at suitable intervals for easy identification.
- Flexible aluminium connectors welded to the main busbars shall be provided wherever deemed necessary.
- The connectors shall be of the same material as the conductor and joints shall be silver-plated to ensure an efficient connection. The bolting schedule and contact pressure shall conform to accepted codes of practice.
- Flexible braided copper connections shall be provided at the equipment terminal such as transformer end and PCC / MCC end connections. Bimetallic connectors shall be provided between the busbar and the copper flexible if the bus conductor shall be of aluminium alloy. The joints shall be capable of 25 mm settlement of the equipment mounting pads. The joints shall be suitably designed to take care of the vibration at the terminals as well as the expansion and contraction of the busbars.
- Expansion joints made of aluminium strips shall be provided wherever deemed necessary, to take care of expansion and contraction of the busbars under normal operating conditions.
- All the above joints shall be tested for temperature rise to prove the adequacy of the design. The maximum temperature rise at the joints shall be less than the specified temperature rise for the busbars.
- The busbar clamps at insulators shall be designed to withstand the forces due to momentary short circuit current. They shall permit free longitudinal movement of the bus bars during expansion and contraction. The material of the clamps shall be aluminium alloy Suitable aluminium spacers shall be provided wherever necessary.
- All bolts, nuts and lock washers used in the bus assembly shall be of high tensile steel, plated for corrosion resistance spring washers of "Beleville" type or equivalent shall be used.
- Suitable splice plates and bimetallic connectors shall be provided wherever necessary.
- Disconnecting links with rating same as that of the main busbars shall be provided in the run of the bus duct to facilitate disconnection of the busbars during testing and maintenance. The separation of the busbar sections with the bolted links removed shall be sufficient to withstand the rated voltage of the bus duct.
- Shorting jumpers, for the purpose of drying out the equipment before commissioning or for carrying out short circuit test on the equipment, rated for the main bus current shall be supplied for shorting the bus duct at a location, adjacent to the disconnecting links.
- The shorting links shall have drilling dimensions matching those of the main bus disconnecting links. Suitable supporting structures and support insulators for the shorting links, if necessary, shall also be offered.

6.11.3 Phase Barriers

- In segregated phase bus duct if metal barriers are provided, the material shall be same as that of the bus duct enclosure material.
- Insulated phase barriers, when specified, shall be made of non-hygroscope insulating material such as fibre glass

6.11.4 Bus Support Insulators

- Within the bus duct the bus shall be mounted and supported on insulators. The insulators shall be mounted on resilient pads provided in the bus enclosure.
- The insulators shall be either porcelain or resin cast flame retardant, non-hygroscopic, high creep and high strength type.
- For bus ducts with voltage rating up to 1100 Volt, Fibre glass / FRP or equivalent type of non-hygroscope insulating supports are acceptable.

6.11.5 Wall Frame Assembly and Seal – off Bushing

- Wherever the bus duct passes through the plant building wall, from indoors to outdoors, a wall frame assembly with seal-off bushings shall be provided to prevent any leakage of rainwater, infiltration of dust and air temperature variations from indoors to outdoors. The wall frame shall be fabricated out of aluminium angles and sheet and shall be suitable for grouting in the wall. It shall be provided with flanges on both sides to receive the bus duct flanges. A suitable size breather shall be provided for the two sections of the bus-duct between the wall frame assembly.
- The bus duct shall be equipped wherever necessary with seal-off bushings to prevent interchange of air at different temperatures. The seal-off bushings shall be flanged type.
- The insulator for wall frame assembly and seal-off bushings shall be of porcelain. Also, the bushings shall be designed for thermal expansion / contraction due to temperature differential for outdoor / indoor use.

6.11.6 Bus Duct Supports

- The supporting structure shall be fabricated from standard steel sections and shall be hot dip galvanized after fabrication. The hot dip galvanizing shall be in accordance with standards.
- Calculations shall be furnished to substantiate the strength support structure to withstand the various static and dynamic loadings.
- The supporting structures shall include supporting members, brackets, hangers, longitudinal beams, channels, nuts, bolts, washers and all other hardware. which are necessary for the erection and support of the entire bus duct installation. All the accessories and hardware of ferrous material shall be hot dip galvanized.
- Studs, nuts, bolts and tapped holes shall conform to the relevant standards. Only hexagonal nuts shall be used. All bolt holes shall be spot faced for nuts.
- Castings and forgings shall conform to respective material specifications and shall be free from flaws. They shall be machined true as per good workshop practice. Welding shall be performed in accordance with relevant recognized standards.
- All threaded pipe connections and fittings, pipe flanges and tube fittings shall comply with relevant standards.
- Indoor portion of the bus duct may be supported from the floor or ceiling beams.
- Outdoor portion of the bus duct shall be supported from ground below on suitable foundation in the ground.

- The foundations and structures in outdoor area shall clear the transformers, transformer foundations, cable trenches.
- All the bus supports shall be adequately supported and braced to successfully withstand normal operation, vibration, thermal expansion, short circuit forces and all specified design loads.
- A separate run aluminium alloy of suitable size clamped along both sides of the enclosure shall be provided as the earth bus. All the parts of the bus enclosure, supporting structures and equipment frames shall be bonded to earth bus. at least two earth pads shall be provided to connect the riser from station earthing bus. All necessary hardware, such as clamps, connectors, etc required for this purpose shall be furnished by the BIDDER.

6.12 Electrical Motors

6.12.1 General

Electric motors shall comply with IS 12615, IS 15999, BS 4999 and BS 5000, IEC 60034, IEC 60072 and IEC 60085 and shall be bi-directional and rated on the basis of duty type S1 (maximum continuous rating).

Where the power supply permits motors shall be preferentially of the 3-phase type. Motors shall be suitable for two starts in succession from hot under the specified duty conditions of load torque and inertia and shall also be suitable for six equally spaced starts per hour under similar conditions.

Motors shall be designed to operate on the supply voltage specified for the Works. Motors shall be capable of operating under conditions of three phase supply imbalance where the negative and zero phase sequence components of the voltage do not individually exceed 2% of the positive phase sequence components.

6.12.2 Applicable Standards

SL. NO.	BRIEF NAME	REFERENCE STANDARDS
1.	Energy efficient Induction motors – Three phase Squirrel Cage	IS – 12615/ IEC 60034-30-1
2.	Standard methods for determining losses and efficiency from tests	IS - 15999(Part2/Sec 1)
3.	Permissible limits of noise level for rotating electrical machines	IS – 12065 / IEC 60034-9
4.	Mechanical vibration of rotating electrical machines	IS – 12075
5.	Guide for testing three phase Induction motors (For standard TEFC SCR motors)	IS – 4029
6.	Methods of determination of efficiency of rotating electric machines (For standard TEFC SCR motors)	IS – 4889
7.	Colours for ready mixed paints and enamels	IS – 5
8.	Electrical insulation -Thermal evaluation and designation	IS – 1271

SL. NO.	BRIEF NAME	REFERENCE STANDARDS
9.	Dimensions of slide rails for electric motors	IS – 2968
10.	Dimensions of vertical shaft motors for pumps	IS – 2254
11.	Values of performance characteristics for three phase induction motors	IS – 8789
12.	Guide for testing insulation resistance of rotating machines	IS – 7816
13.	Designation for type of construction and mounting arrangement of rotating electrical machines	IS – 2253
14.	Guide on effects of unbalanced voltages on the performance of three phase cage induction motors	IS – 13529
15.	Guide for selection & application of three phase induction motors for different types of driven equipment	IS – 13555
16.	Code of practice for installation and maintenance of induction motors	IS 900
17.	Dimensions of foot mounted AC Induction motor.	IS -1231
18.	Dimensions of flange mounted AC Induction motors	IS – 2223
19.	Rotating electrical machines – rating & performance	IS-15999 /IEC 60034-1
20.	Degree of protection provided by the integral design of rotating electrical machines (IP code): classification	IS/IEC 60034-5
21.	Designation of method of cooling for rotating electrical machines / method of cooling (IC code)	IS 6362 / IEC 60034-6
22.	Terminal markings and direction of rotation for rotating electrical machines	IS/IEC 60034-8
23.	Dimension & output rating of rotating electrical machines	IEC 60072-1

6.12.3 Construction

Motor construction shall provide a degree of protection as follows:
IP 55 - use in applications in dusty environments.
IP 65 - external use in exposed location.
Motor mounting arrangement shall be to suit application.

Motor cooling shall be totally enclosed fan cooled (TEFC) with shaft driven bi-directional fans. Type of cooling shall be IC 411 as per applicable standard. Other forms of ventilation may be used with the approval of the Engineer.

Motor bearings shall be provided with facilities to add additional lubricant. For grease lubricated bearings grease nipples shall be provided and a grease relief feature incorporated. Oil lubricated bearings shall be provided with site glasses which provide an accurate indication of bearing oil level when the motor is in use. Bearings shall minimum L-10 rating of 5 years (40,000) hours at rated operating condition. Motors rating of 37 kW and above shall have online greasing facility and ratings below shall be provided with sealed bearing.

Stainless steel rating shall be provided with information of ratings, type of enclosure, starting current, starting torque and efficiency class. Separate tag plates shall be provided for space heater, thermistor, RTD.

Motors shall be designed for normal sound power as defined by IS 12615, IS 15999, IEC 60034 or BS 4999 and windings shall be insulated to class F as defined by IS 11182 or BS 2757. However, temperature rise at full load shall be limited to that for Class B insulation.

Where specified motor windings shall incorporate:

- Thermistors (PTC type), or
- Resistance thermometers (PT 100).

In each instance the temperature detecting devices shall be in close thermal contact with each phase of the stator windings. All thermistors shall be connected together to provide a single electrical circuit for connection to an external relay which shall be capable of tripping the motor.

Each resistance thermometer shall be connected separately to an external monitor relay which shall offer alarm and trip settings. Thermal protection shall be Class I for sizes of motor up to 75kW and Class II above 75kW.

6.12.4 Performance and Characteristics of LT Motor

(i) Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under either of the following supply conditions:

Supply Condition

(a)	Variation in supply voltage from rated voltage	±10%
(b)	Variation in supply frequency from rated frequency	±5%
(c)	Combined voltage and Frequency variation	+10%

(ii) All Motors shall be suitable for the method of DOL starting or star-delta starting or any other method of starting.

(iii) The minimum permissible voltage shall be 80% of the rated voltage during motor starting.

(iv) Motors shall be capable of starting and accelerating the load with the applicable method of starting, without winding temperatures reaching injurious levels, when the supply voltage shall be in the range of 85% of the rated motor voltage to maximum permissible voltage.

(v) The locked rotor current of the motor shall not exceed 600% of full load current (subject to tolerances as per the applicable standard) unless otherwise specified. The locked rotor current of VFD controlled motor shall be within the limit of IS 12615 / IEC 60034.

(vi) Motors shall be capable of developing the rated full load torque even if the supply voltage drops to 70% of the rated voltage. The pull-out torque of the motor shall be at least 205% of full load torque.

(vii) Motors when started with the driven equipment coupled shall be capable of withstanding at least two successive starts from cold conditions & one start from hot condition without injurious heating of windings. The motors shall also be suitable for three equally spread starts per hour under the above referred supply conditions.

(viii) Motors shall be of Energy Efficient type.

(ix) LT motors should have the following provision:
For Motor > = 30 kW, anticondensation heaters and separate auxiliary terminal box for heaters shall be provided.

Motors rated below 30kW, during idle periods, the stator winding shall be connected to a 24V 1-phase 50 Hz, AC supply for heating and elimination of moisture. The bidder / manufacturer shall bring out in case of any objection to the above method of heating stating reasons thereof. A warning label, black letters on a yellow background shall be fitted to indicate that the heater may be energised. Heater terminals shall be shrouded on larger motors a separate terminal box shall be provided.

Anti-condensation heaters shall be sized to raise the temperature inside the motor several degrees above the dew point temperature, the heater surface temperature should not exceed 200°C. Heaters shall be automatically disconnected when the motor shall be switched on.

(a) Vibration monitoring system shall be provided for measuring vibration in motor body and bearing for Motors > = 75 kW.

6.12.5 Specific Requirements of VFD Driven Motors

The motor shall be suitable for operation with a solid-state power supply consisting of an adjustable frequency inverter for speed control. The motor shall be suitable for the current waveforms produced by the power supply including the harmonics generated by the drive. The motor shall be designed to operate continuously at any speed over the range of rated speed.

The permitted voltage variation should take into account the steady state voltage drop across the AC drive and all other system components upstream of the motor. The motor shall be constructed to withstand torque pulsations resulting from harmonics generated by the solid-state power supply.

The driven equipment manufacturer shall be solely responsible for proper selection of the motor for the given load application and the output characteristics of the driven equipment

6.12.6 Local Push Button Station

For all motors Local Push Button station shall be supplied shall be provided near the motors/ apparatus for controlling supply to the motor apparatus at an accessible location. For local control of motors, LPBS shall be provided suitable for wall / pedestal mounting. The Local Push Button station shall be complete with all the indication lamps, pushbuttons and shall have the specifications as listed below.

The degree of protection for LPBS shall be IP55 with canopy for outdoor and IP54 for indoor applications. The enclosure shall be made of 2 mm CRCA sheet steel and the interior and exterior of push button stations shall be painted light grey with shade no 631 of IS:5 as per standards.

Minimum Push button for ON / OFF / E-Stop and Local / Off / Remote Selector Switch and indication lamps (ON / OFF / TRIP) should be provided. Reverse push button shall be provided for bi-directional motors. The Emergency push button shall be of red mushroom head, press to lock & turn to release type.

All push buttons shall be provided with 2 nos. NO and 2 nos. NC contacts for various interlocking purposes. One contact of stop PB shall be directly wired to the switchgear module for direct tripping and another contact to control system.

The stations shall have sufficient number of terminal blocks with 20% spare. The wirings shall be done with 1.5 Sq.mm, multistrand copper, 1.1kV grade PVC insulated, grey colour, highly flexible wires having ends provided with identification ferrules and crimped tinned copper logs. Suitable plugs are to be provided to seal the unused cable entry opening. The glands shall be double compression brass type and shall be weatherproof. The local Push button shall be mounted at 1200mm from the floor level.

The PB station shall be suitable for wall or structure mounting, provided with labels, earthing terminals, suitable lugs glands.

PB station shall be of one of the following types

Type A - Three PB's forward-reverse-Stop for reversible motors.
Type B - Two PB's start-stop for non-reversible motors.
Type C - One PB STOP for emergency.

6.12.7 Cable Terminations

Cable termination boxes shall have IP 55 and shall be suitable for air termination of cables. They shall be sealed with a neoprene gasket to provide dust and weather protection. Terminal box shall be suitable for top and bottom entry of cables and shall be capable of rotation in steps of 90 Deg through 360 Deg.

Cable boxes for voltages in excess of 1000 shall be treated with anti-tracking varnish.

Separate terminal boxes shall be provided for space heater, thermistor with caution plates.

When single core cables are used, gland plate shall be non-magnetic material.

6.12.8 Junction Boxes

For LT motors of 18kW and above, power junction boxes shall be provided where 3 core aluminium shall be terminated, and copper flexible cables shall be taken from it to the motor terminals.

The degree of protection for JB shall be IP55 for outdoor and IP54 for indoor applications with 20% spare terminals.

6.13 Cables: MV, LV Power, Control and Telecommunications

6.13.1 Applicable Standards

The cables shall conform to the latest applicable standards specified below

SL. NO.	ITEM	
1.0	**APPLICABLE STANDARDS**	
1.1	Type of conductor	IS 8130 IEC 60228
1.2	Conductor Screening	IS 7098 IEC 60502
1.3	Insulation	IS 5831 IS 7098

SL. NO.	ITEM	
		IEC 60502
1.4	Armouring	IS 3975
1.5	Test and test equipment	IS 10810
1.6	Oxygen Index test	ASTM-D-2863
1.7	Temperature index value	ASTM-D-2863 / NES 715
1.8	Cable drums	IS 10418
1.9	Flammability	IS 10810 IEC 60331 IEC 60332 IEEE 383 SS 424-1475
1.10	Test for smoke generation	ASTM-D-2843
1.11	Test for acid gas generation	IEC 60754-1
1.12	Tests for Resistance to Ultraviolet Radiation	DIN 53387
1.13	Telecommunication cable, Low frequency cables and wires with PVC insulation and sheath - General Tests and measuring methods	IS 5831 IEC 60189-1 IEC 60189-2
1.14	Instrumentation cable	IEC 60189-1 IEC 60189-2
1.15	Construction, performance and testing of XLPE Insulated MV Power Cables	IS 7098 IEC 60502
1.16	Construction, performance and testing of 1100 V Grade PVC Insulated Power and Control Cables	IS 1554 IEC 60502
1.17	Construction, performance and testing of 1100 V Grade light duty unarmoured cables	IS 694
1.18	Instrument cable for operating temperature up to 400 deg centigrade	JSS 51034
2	Installation of Cables	IS 1255
3	Recommended Cable Ratings	IS 3961

6.13.2 Features of Construction

(a) XLPE Insulated MV all aluminium stranded Power Cables:

The Cables shall be 11kV unearthed grade, heavy duty, stranded aluminium Conductor, grade H4, Class 2, XLPE Insulated, Conductor Screening by extruded. Semiconducting compound, insulation screening through combination of semi conducting compound and non-magnetic tape (Copper tape), inner sheath over laid up cores, galvanized steel wire / strip armoured (Aluminium wire armouring for single core cables), outer sheath of extruded black PVC Compound type ST-2 Core Identification shall be by printed numerals.

(b) LT Power Cables

XLPE Insulated Cables:

The Cable shall be 1.1kV Grade, grade H4, Class 2, heavy duty, stranded aluminium for above 6 sq.mm, annealed Copper Conductor class 2 for 6 sq.mm and below, XLPE, insulated, inner sheathed, galvanized steel wire / strip, armoured, extruded black PVC Compound type ST2 outer sheathed.

(c) Control Cables:
The Cables shall be 1.1kV grade, heavy duty, stranded copper conductor, extruded PVC Compound type A Insulated, galvanized steel wire / strip armoured with extruded PVC inner sheath and extruded black PVC type ST1 outer sheathed.

6.13.3 Cable Rating

The Contractor shall ensure that cable and wires associated with the distribution and control systems, plant wiring and all other installations throughout the works are adequately rated for their use.

In assessing the rating of any cable or wire, the following factors shall be taken into account:

- Supply voltage and frequency:
- Maximum voltage drop permissible.
- Type and magnitude of load.
- Fault level and duration related to circuit protection relays and fuses.
- Circuit over current protection.
- Route length and disposition of cables.
- Ambient temperature.
- Method of installation.

All power cables shall be sized for continuous current carrying capacity at the ambient temperature of 45^0C. The design current capacity of any circuit shall not exceed the full load current of the supplied device by at least 10%. Power cables shall be sized to limit the maximum voltage drop to not more than 3%.

Under motor starting conditions the corresponding voltage drop shall not affect the operation of the motor controls or the ability of the motor to start and run effectively and in any event shall not exceed 10%. The Contractor when sizing cables for the remote operation of shunt trip coils shall take due account of the voltage drop caused by the momentary current surge taken at the instant of energisation. MV and LV cables shall be sized for a fault clearance time of 1 second for the incoming feeders and 0.5 second for switchboard feeders controlled by circuit breaker.

6.13.4 Cable Colours

All cable cores shall be colour coded throughout their length and shall be so connected between switchboard, distribution board, plant and accessories, that the correct sequence or phase colours are preserved throughout the system.
The colour coding should be as follows:

3 phase	red, yellow and blue
single phase or dc	red and black
earth	green / yellow
control	blue (dc), red (ac)

6.13.5 Cable Conductors

Copper conductors shall be used for cables of sizes up to 6 Sq.mm and above 6 Sq.mm Aluminium conductors shall be used. Cores of cross-sectional area greater than 1.5 Sq.mm shall be stranded.

Lighting final distribution circuits shall be of a minimum cross-section of 1.5 Sq.mm. Power cables shall be of a minimum cross-section of 2.5 Sq.mm. Internal wiring of control panels shall be of a minimum cross-section of 1.0 Sq.mm flexible and stranded Control cables shall be of a minimum cross-section 1.5 Sq.mm for external use and 1.0 Sq.mm for internal use.

6.13.6 Cable Numbering

All cables shall be allocated a unique number which shall be fixed to each end of the cable using a corrosion resistant label. Cables of different categories shall be tagged with the following subscripts and three-digit number

MV power	MV-P_ _ _
LV power	P_ _ _
Control	C_ _ _
Instrumentation	I_ _ _
Protection	PR_ _ _

6.13.7 Cable Drums

Cables shall be supplied in non-returnable wooden drums. The wood used for construction of the drum shall be properly seasoned and free from defects and wood preservative shall be applied to the entire drum. All ferrous parts shall be treated with a suitable rust preventive coating to avoid rusting during transit or storage.

The Bidder shall indicate in the offer, the maximum length for each size of cable, which can be supplied on one drum. The actual length supplied on each drum shall be within tolerance limit of ± 5% without any tolerance on total ordered quantity of each size of cable. However, before winding the cables on drums contractor shall obtain Employer's approval for the drum lengths.

Each drum or coil of cable shall be accompanied by a certificate with the manufacturer's name, cable size and number of cores, length, result and date of tests as required in the Employer's Requirements. Cables manufactured more than 12 months before delivery shall not be accepted. All cables shall be delivered with cable ends effectively sealed by hygroscopic scaling caps. When a cable is cut from a drum both ends shall be immediately sealed to prevent ingress of moisture. Cables shall not be transported to site in loose coils but a number of short lengths of cable may be transported on the same drum. The Contractor shall be wholly responsible for the purchase and / or hire costs of all cable drums and for the removal of these drums from site after use.

6.13.8 Cable Installation

General

Cables shall be installed in such a way that the minimum bending radii are not reduced when installed or during installation. Cables shall not be installed in ambient temperatures below that recommended by the cable manufacturer.

Cables grouped together shall have insulation capable of withstanding the highest voltage present in the group.

Cable fire sealing shall be provided such that fireproof cable penetration seals rated for two hours shall be provided as per BS: 476 (Part - 20) or equivalent standards.

Cables of different categories shall be installed so as to maintain satisfactory clearances for safety and in order to reduce the possibility of electrical interference. The following table details the distances in mm that shall be maintained between the different categories of cable.

Table of Separation Distances in mm between different Categories of Cable

Cable Category	MV Power	LV Power	C&I/Protection
MV Power	Not specific but shall suit de-rating factor	300	600
LV Power	600	Not specific but shall suit de-rating factor	300
C & I / Protection	600	300	Not specific but shall suit de-rating factor
Gas/Water main	300	300	300

These separations are minimum and special circumstances such as the presence of high current flows, or harmonic content may necessitate larger separation distances.

In order to make economic use of the cable support system, cables shall be arranged in groups of 50 mm maximum overall diameter. These groups shall be securely tied to the cable support system at intervals not exceeding 900 mm for horizontal runs and 300 mm intervals on vertical runs.

Cables shall be laid in a manner such that any electrical interference between cables shall not have a detrimental effect on the life and operation of Plant.

Where practical a separate cable support system shall be provided for power and non-power cables. Where this is not practical a separation of 150 mm shall be maintained between power and non-power cables when run on the same support system.

Heavy duty galvanized iron cable tray and ladder racking shall be used for cable support systems. FRP or GRP cable trays along with support systems/ accessories shall be provided in areas used for the storage and handling of chlorine and chemical areas. These systems shall be used to route cables around walls and routed overhead. Necessary cable supports from building/structure ceiling/ wall/ columns etc. depending on cable routing shall be considered. Cable ladder supports shall be provided for cables routed from cable pull pits to overhead cable trays. Vertical cable tray supports shall be provided for all cable tray dropping from overhead tray and upto the equipment/panel/DB level. Cables shall be securely fixed to the support systems and bundling of cables shall be permitted where allowance for this practice has been made in sizing the cables.

6.13.9 Cables Laid Direct in Ground

Buried cable installation shall be as per IS 1255 with up to 650 / 1100V shall have a minimum cover of 750 mm and for cables of 11kV and above shall have cover of min. 900 mm cable measured to the top of the highest cable. Cables at road crossing shall be installed in RCC Ducts with a minimum cover of 1000mm from top of road level. There shall be cable pull pits connecting the RCC duct at either ends of the road crossings. Cable pull pits shall be provided at all building cables entry/exit points.

Cables of greater than 650 / 1100V shall be buried with a minimum cover of 1 m.

The bottom of the cable trench shall be freed of sharp stones and such like and 75 mm of sieved sand laid below the cable. After cable laying 75 mm of sieved sand shall be laid above the cable. Interlocking cable protective covers, minimum 1 m long x 300 mm wide, marked ‘Danger -Electric Cable’ in English

and the vernacular shall be laid on top of the sieved sand covers shall extend the whole length of the cable trench and shall overlap cables by a minimum of 50 mm. Warning tape shall be laid a minimum of 200 mm above the protective covers. Cables are to be installed without tees or through joints unless otherwise approved by the Engineer Single core cables shall be run in trefoil formation.

6.13.10 Cables Laid in Underground Ducts

Underground ducts shall be constructed of impact resistant PVC-U and laid at a minimum depth of 500 mm, ducts shall be surrounded by at least 75 mm of sieved sand except at road crossings where it shall be 1 m deep and encased on all sides by 150 mm of concrete.

The Contractor shall ensure that sufficient draw-in points have been provided and that adequate room has been allowed for installation of cables. Drawstrings shall be provided in all ducts to enable additional cables to be installed when required.

Where cables pass in or out of any duct entries into or within buildings such entries, together with any spare ducts shall be sealed against the ingress of moisture by means of duct stoppers and bituminous compounds or by any other method approved by the Engineer. The stopper shall have a fire resistance of at least 30 minutes. Single core cables in trefoil formation shall pass through the same duct and shall not be separated.

6.13.11 Cables installed in Conduit

(a) General

Conduits shall be galvanized heavy gauge solid drawn or welded screwed steel type and be in accordance with IS 9537 Part 2 or BS 4568. Accessories shall either be malleable cast iron screwed type or pressed steel and galvanized.

A space factor of 40% shall not be exceeded, but in any case, conduit of less than 20 mm diameter shall not be permitted. The tubing shall be perfectly smooth inside and out and free from flaws and imperfections of any kind. Both ends of every length of tubing shall be properly reamed with all sharp edges removed before erection.

Where several conduits converge, malleable cast iron or heavy gauge sheet steel adaptable boxes shall be employed in order to avoid crossings. Conduits shall be connected by means of male brass bushes and couplings.

Where conduits are greater than 25 mm, straight through joint boxes shall be of the trough type. Where conduit and / or fittings are attached to equipment casings, the material or case of the casing shall be tapped for a depth of not less than 10 mm or male bushes and flanged couplings shall be used.

Heavy hexagonal lock nuts shall be used at all positions where running joints are required and great care shall be taken to ensure that they seat firmly and evenly on to the mating faces of coupling or other adjacent accessories. All junction boxes, draw-in boxes, and inspection fittings shall be so placed that the cables can be inspected and, if necessary, withdrawn and re-wired throughout the life of the installation.

Generally, not more than two bends or offsets or one coupling shall be permitted without a suitable inspection accessory. Fish wires shall not be left in conduits after erection. The whole of the installation shall be arranged for a loop-in type of system with joints being carried out at switches, isolators, etc Intermediate joints in the cable shall only be allowed by arrangement with the Engineer. Where terminal blocks are necessary, they shall be of the porcelain type with brass pinching screws.

Ends of conduits which are liable to be left open for any length of time during building operations shall be plugged to prevent the ingress of dirt, cement, etc and covers, either temporary or permanent, shall be fitted on all boxes.

Generally, conduits shall not cross expansion joints of buildings, but where they cannot be installed in any other manner then a flexible conduit shall be used across the expansion joint A total 150 mm movement shall be allowed.

(b) Surface Installation

Surface conduits shall be secured and fixed by means of distance spacing saddles or approved purpose made clips which allow the conduits to be taken directly into accessories without sets or bends. Conduits shall be run in a square and symmetrical manner. An efficient means shall be adopted to provide for the drainage of condensation and the runs shall be properly ventilated.

All surface conduit runs shall be marked out for approval by the Engineer before the installation shall be carried out. Where large multiple parallel conduit runs would occur, use may be made of galvanized cable trunking. Conduits installed on structural steelwork shall be secured at spacing not exceeding those for surface conduit by girder clips, otherwise fixing shall be as for surface conduits on walls, drilled and tapped to the metalwork Power driven fixings shall only be used with the express permission of the Engineer. Any drilling or access which shall be required through any structural member of the building shall be agreed with the Engineer before carrying out the work.

Exposed threads and places where galvanizing has been damaged shall be cleaned and then painted with two coats of an approved metallic zinc-based paint. This treatment shall be applied as the work proceeds.

(c) Concealed Installation

Concealed conduits shall be securely fixed to prevent movement before laying of screeds, floating of plaster, casting of columns or other building operations necessary after the conduit installation. Crampets or similar fixings shall be used for attaching the conduit to brick work, etc. Building nails shall not be accepted.

At least 15 mm cover shall be allowed for finishes over the conduit. Where this cover cannot be maintained then expanded metal shall be fitted with the conduit. Conduit cast into reinforced concrete floors shall be fixed to the steel reinforcing with binding wire and the conduit boxes filled with expanded polystyrene or enclosed in a plastic bag to prevent the ingress of concrete when poured. Where possible, the conduit boxes shall be fixed to shuttering to give a flush finish.

Conduit installed in voids, false ceilings, and other concealed routes shall be installed as specified for the surface conduits. Wiring shall be carried out after the false ceiling or permanent ducts have been completed. Conduit installed in floors shall be sealed against ingress of moisture.

The conduit installation shall be inspected by the Engineer before the building operation conceals the work.

6.13.12 Cable Installed in Flexible Conduit

Flexible conduit shall be of the waterproof galvanized type or PVC wire-wound type with cadmium plated mild steel couplings. Lengths of flexible conduits shall be sufficient to permit withdrawal, adjustment or movement of the equipment to which it shall be attached and shall have a minimum length of 300 mm. Flexible conduit shall not be used as a means of providing earth continuity. A single earth conductor of adequate size shall be installed external to the conduit complete with earth terminations.

Where conversion from rigid conduit to flexible metallic conduit shall be made, the rigid conduit shall terminate in a through type box and the flexible conduit shall extend from this box to the equipment, the earth continuity cable shall be secured to the box and to the piece of equipment by properly designed earthing screws. The use of lid facing screws, etc. shall not be permitted. Adapters shall incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.

6.13.13 Cable Installed in Cable Trunking – Metal

Cable trunking shall be manufactured from mild steel of not less than 125 mm and shall be hot dipped galvanized. The Contractor shall ensure that the size of the trunking shall be adequate for the number of cables to be installed together with 50% spare capacity and shall in any case be 50mm x 50 mm minimum size.

Segregation of cables shall be carried out if required using continuous sheet steel barriers with the bottom edge welded to the trunking.

The trunking shall have two return flanges for rigidity. Where necessary, additional strengthening straps shall be fitted internally. The cover shall overlap the trunking and be made of the same gauge. Fixing screws for covers shall be recessed and be of the self-retaining `quick fix' type. All bends, tees and intersections shall be of the gusset type and shall, wherever possible, be purpose made by the manufacturer and of a matching design to the main trunking.

Cables shall be retained in the trunking when the cover shall be removed by means of straps. Internal connecting sleeves shall be fitted across joints in the trunking and earth continuity ensured by bonding each section of trunking to a continuous earth wire.

Non-flammable fire barriers shall be inserted where the trunking passes through walls or floors. Conduit connections to trunking shall be made by flanged couplings and male bushes. Trunking shall be supported at intervals not greater than 2 m horizontally or 25 m vertically. Crossings over expansion joints shall be made in flexible conduit.

Should it be necessary to cut or drill a section of trunking or a trunking fitting the bared ends shall immediately be given a coat of zinc rich cold galvanizing paint.

Cable and conduit / trunking runs shall be determined by the Contractor and agreed by the Engineer before any work shall be started. The run shall be at least 150 mm clear of plumbing and mechanical services. Conduit / trunking systems erected outside a building shall be weatherproof.

6.13.14 Cable Installed on Cable Tray

Cable tray shall be of perforated sheet steel with formed flanges and of minimum thickness not less than 1.5mm for trays up to 100mm width, perforated / ladder type with minimum thickness not less than 2mm for trays above 100mm to 300mm width and 2.5mm for trays above 300mm width. Exterior perforated cable trays shall be covered with cable tray covers.

Cable tray shall be hot dipped galvanized. Cable tray for use in areas where chlorine gas may be present shall construct from U-PVC or GRP Cable tray supports shall be of a compatible finish with the associated cable tray.

All cable tray tees, intersection units, bends, turns and sets shall, whenever possible, be purpose made by the manufacturer and shall be of a matching design to the main section of cable tray.

Tray shall only be joined by couplers supplied by the manufacturers. The joint shall be secured in accordance with the manufacturer's instructions.

Cable tray supports supplied by a manufacturer or made up on site shall be of ample strength to maintain rigid support to the fully laden cable tray along its entire length and shall ensure that the deflection of any one section does not exceed 15 mm at mid-span.

Wherever possible, cable trays shall be installed in full lengths without cutting. Should it be necessary to cut or drill a length of tray, then for galvanized trays, the bared ends or damaged section of the tray shall immediately be given a coat of zinc rich cold galvanized paint. All site manufactured accessories, supports and metal fittings required to ensure correct installation of the cable trays shall be similarly treated.

All cables shall be firmly secured to the tray using purpose made saddles, as approved by the Engineer, together with proprietary nylon fasteners and / or cable cleats. Following installation of cables, the tray shall remain rigidly supported and the deflection of any section shall not exceed 15 mm at mid-span. All brackets and tray work shall be suitable for withstanding a temporary weight of 125 kg.

Cable trays shall not be cut to allow the passage of cables through the surfaces of the tray. The sizing of the cable tray shall provide a minimum of 25% spare capacity. The tray shall be run at least 150 mm clear of plumbing and mechanical services.

6.13.15 Cable Installed on Ladder Rack Systems

Ladder racking either light or heavy weight shall be proprietary item and installed in accordance with manufacturer's instructions. Bends in the installation shall take account of the minimum bending radii of cables to be installed. Cables shall be clipped to the ladder rack using clips designed for the system in use and appropriate to the type and size of cable installed. The sizing of the cable rack system shall provide a minimum of 25% spare capacity. The ladder racking shall be run at least 150 mm clear of plumbing and mechanical services.

6.13.16 Cable Clipped Direct

All cable hangers, clips, cleats and saddles shall be of an approved type and appropriate to the type and size of cable installed. Their spacing shall be such as to ensure a neat appearance and prevent sagging of the cables at all times during their installed life.

6.13.17 Cable Installed in Internal Floor Trench

(a) In Shallow trenches (maximum depth 500 mm)

In shallow trenches used for electrical services only, cables may be laid in a neat and orderly manner on the floor of the trench. One layer only shall be allowed. Additional cables shall be installed on the walls of the trench in an approved manner. Here the trench shall be shared by other services, cables shall be installed on the walls of the trench in an approved manner.

(b) All other trenches including walk through service ducts

Cabling shall be installed to the walls of the trench in an approved manner. Where other services are present the cables shall be segregated from them and wherever possible kept above 'cold' 'wet' services. Cables should not be run, if at all possible, above or in close proximity to 'hot' services. The cabling shall be installed in such a manner as to allow access to the other services for normal maintenance without disturbance of the electrical installation.

6.13.18 Cable Terminations and Joints

(i) **Power Cable Terminations**

Power cables shall be terminated in suitable boxes arranged for bolting to switchgear, motor starters and motors. Cores shall have either crimped lugs or sleeves to match either post terminals or bolted clamp terminals.

Each cable entry into a terminating box shall be made through a suitable gland, which shall have provision for securing the armour where applicable. Where single core glands are required, these shall be of the non-magnetic type and the associated box bottom plate, where the core passes through, shall not have a continuous magnetic path.

Adequate provision shall be made to bond the cable armouring to the box and / or switchgear casing of a suitable size to withstand the prospective short circuit fault current of the system, glands shall be fitted with earth bonding tags where intimate screwed contact between gland and cable box shall not be possible.

Where cable glands are exposed to the weather these shall be protected by heat shrink plastic sleeve or purpose moulded sleeves covering the gland continuously from overall sheath to the gland neck.

Where terminations of multicore type have to be made on to items of plant which have to be dismantled for maintenance, these shall be made off through glands into an adaptable box containing terminals and flexible single cores taken into the equipment via flexible waterproof plastic covered conduit, and a separate earth core linking the box to the equipment.

Where cables are glanded to or passed through cabling plates the gland plate or cabling plate shall be constructed of non-magnetic material.

(ii) Power Cable Joints

Through joints shall only be allowed with the approval of the Engineer. Where such joints are necessary in thermoplastic and elastomeric cables, the cables shall be jointed with epoxy or acrylic resin cold setting compound, which has been premeasured and pre-packed ready for use. The boxes shall preferably be of split, moulded plastic type with filling vents for compound. Bonding straps shall be fitted with armour clamps across the joint and inspected by the Engineer prior to filling the box with compound. Wrapped pressure type joints shall not be accepted. In case of HT cable end termination and straight through joints shall be approved heat shrinkable type. High voltage test shall be conducted, and test reports and megger values shall be submitted after test along with calibration certificates of the instrument used for measuring.

(iii) **Multi core or Control Cable Terminations**

A sufficient number of terminals shall be provided to terminate all cable cores including 10% spare cores. For control and auxiliary wiring an additional 20% of this number shall be provided as spares.

Not more than one core of internal or external wiring shall be connected on any one terminal. Where duplication of terminal blocks are necessary, purpose-made solid links shall be incorporated in the design of the terminal blocks.

Terminals which remain energized when the main equipment shall be isolated shall be suitably screened and labelled.

Terminal blocks for different voltages or circuit type shall be segregated into groups and distinctively labelled.

6.13.19 Cable Fixings

Ties and strapping shall be suitable for securing cable and cable groups to cable tray or ladder. They shall be resistant to chemical and marine corrosion Plastic coated metal ties used in order to obtain corrosion resistance shall not be acceptable. Nylon ties shall be resistant to the effects of ultra-violet light and shall be self-extinguishing. Large single cables shall be secured with cable clamps or cable cleats.

Cable Identification

At each end of each cable, in a uniform and visible position a label shall be fixed on the cable in accordance with the cable schedule. Labels shall be made of PVC and shall be indelibly marked to the approval of the Engineer. The label shall be retained using proprietary nylon strips passing through two fixing holes at either end of the label. If the cable gland shall not be normally visible, then the label shall be fixed inside the panel by means of screws.

6.13.20 Cable Glands

Glands shall generally be of the mechanical double compression hexagon type earth continuity of brass glands shall confirm to BS: 6121 / EN 50262. This may be achieved by the rigid clamping of the armour within the gland and the intimate contact between the threaded components of the gland and the equipment.

Each gland shall be installed complete with proprietary earth tag providing a ready means of connecting a flexible strand or strip earth bond to the gland at any position around the gland in relation to the associated apparatus. Adequate earth continuity shall be assured between the earth tag, the gland and the armour wires of the cable where applicable.

Glands for single core cables shall be constructed from non-magnetic materials. Each gland shall be installed complete with a proprietary non-ferrous locknut to secure the gland body to the equipment where the entry hole is plain, i.e., not tapped. Where holes for cable entries are not provided it shall be the responsibility of the contractor to mark out and drill such holes Burrs and swarf shall be removed, care being taken to ensure that swarf and filings, etc do not enter the equipment.

For non-hazardous areas cable glands in situations where moisture may be present shall be double seal weatherproof type, gland shrouds shall be used, and entry shall be sealed. For dry indoor situations, standard industrial glands with shrouds are acceptable. For hazardous areas, glands conforming to EExd (Explosion-proof and flameproof) standard shall be used with double seal and shroud.

Power cable glanding arrangements in hazardous areas shall incorporate an insulated adapter and earth link. This shall provide the facility to disconnect the armouring from the glanded device in order that a true earth loop value may be measured when carrying out tests on the installation. Cable Glands shall be suitable for indoor and outdoor use, appropriate for single wire armoured, plastic or rubber sheathed cable. Which provides grip to the cable with outer and inner seals suitable for all climatic conditions weatherproof and waterproof. The outdoor cable glands shall be provided with shrouding.

Marking Locations of Underground Cables

The location of all underground cables shall be engraved on brass or other non-corrodible plates to be fixed to the exterior surface of all walls of buildings 300 mm above ground level and directly above the point where cables pass through the wall.

In addition, concrete route marker posts shall be installed at intervals of not more than 50 m at all junctions and changes of direction along the cable route and cable joint markers shall be provided

wherever undergrounding cable joint exists. Such marker posts shall be not less than 200 mm high and of substantial construction.

A drawing or sample of a typical marker post shall be submitted for the approval of the Engineer. The markers shall be marked 'electric cable' / 'cable Joint' in English and the vernacular.

6.13.21 Drawings and Data

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, test certificates etc, shall be submitted along with the bid / after award of contract as specified under, "Bid / Contract Drawings", Part 3, General Requirements, Volume - 2 of Bid Documents.

6.14 Cable Carrier System

6.14.1 General

The cable carrier system covers the supply of cable racks, cable trays and its supporting accessories.

6.14.2 Applicable Standards

Steel for general structural purposes	:	IS:2062
Dimensions for hot rolled steel beam column channel and angle sections	:	IS:808
Code of practice for use of metal arc welding for general construction in mild steel	:	IS:816
Hot deep galvanizing of iron & steel	:	IS:2629
Methods of testing uniformity of coating of zinc coated articles	:	IS:2633
on structural Hot dip zinc coatings steel and other allied products	:	IS:4759

6.14.3 Cable Racks, Trays and their support structure

(a) Cable racks / trays shall be fabricated from standard structural steel members.

(b) All cable trays, vertical raceways, cable racks and cable tray supporting structures shall be hot dip galvanized.

6.14.4 Galvanising

Wherever galvanizing has been specified, the hot dip process shall be used. The galvanized coating shall be of uniform thickness. Weight of Zinc coatings for various applications shall not be less than those indicated below:

(a) Fabricated Steel	
Thickness less than 2 mm, but not less than 12 mm	340 gms/sqm
Thickness less than 5 mm, but not less than 2 mm	460 gms/sqm
Thickness 5 mm and over	610 gms/sqm
(b) Fasteners	
Up to nominal size M10	270 gms/sqm
Over M10	300 gms/sqm

Galvanizing shall be carried out after all drilling, punching, cutting, bending and welding operations have been carried out. Burrs shall be removed before galvanizing. Any site modification of galvanized parts such welded joints, fabricated cable trays and supports should be covered well by zinc rich primer and aluminium paint.

6.14.5 Drawings and Data

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, test certificates etc shall be submitted along with the bid / after award of contract as specified under, "Bid / Contract Drawings", Part 3, General Requirements, Volume - 2 of Bid Documents.

6.15 Lighting System

6.15.1 General Requirements

LED lighting shall be considered for indoor and outdoor lighting. The Lighting system includes the following items

(i) Lighting fixtures complete with Lamps and accessories (lumen per watt shall be indicated).
(ii) Lighting system equipment (ISI make).
- Light control switches, receptacle units with control.
- Switch units, lighting wires, conduits and other similar items necessary to complete lighting system.
- Lighting fixture supports, street lighting poles and flood light towers.
- Main Lighting distribution board, lighting panels.
- Multi core cables for street, boundary and flood lighting.

LED Requirements

- High Power White LEDs are used in the luminaries and the Wattage of these LEDs would be greater than ONE watt.
- LED shall be operated at a forward current of less than 90% of the rated current.
- Colour Rendering Index (CRI) of the LEDs used in the luminaire shall be greater than 70.
- The illumination of the luminaries shall be uniform without dark bands or abrupt variations and soothing to the eye.
- Light Uniformity Ratio (E_{min} / E_{avg}) shall be as per National Lighting Code, National building Code.
- Luminary Body Temperature would be less than 30 deg C above the ambient, even after continuous burning of Luminary for 24 Hrs.
- The Luminaire works on single phase three wire system (Phase, Neutral & Earth).

6.15.2 Construction of LED luminaires

(a) The luminaire housing shall be made up of corrosion-free high-pressure aluminium die cast, thus confirming the luminaire to IP-65 protection and safety as per IEC 60598-1.
(b) The Luminaire shall be equipped with distortion free, clear, Heat Resistant toughened, UV stabilized glass cover in the front fixed to the die cast Aluminium frame which would be fixed to the housing by means of stainless-steel screws.

The minimum technical specifications for LED lighting shall be as follows:

(i) Powered by the latest high-efficiency bright LEDs that meet the LM-80 standard.
(ii) Average rated life span of 50000 hrs.
(iii) LED lumen output shall be greater than 125 Lumens/watt.

(iv) Luminaries' lumen output of at least 80 Lumens / watt.
(v) Input voltage range 90-300 V.
(vi) Power factor > 09.
(vii) THD < 15%.
(viii) Ingress protection as per IP 65.
(ix) Operating temperature: -5°C to 50°C.
(x) Storage temperature: -5° to 70°C.
(xi) Humidity 10% - 100%.
(xii) LEDs shall be operated at a forward current less than 90% of its rated current.
(xiii) The LEDs used in the luminaire shall have minimum angle of 120 degree.
(xiv) Colour rendering index (CRI) of the LEDs shall be greater than 70.
(xv) Conform to Photo Biological Safety for the LEDs as per IEC 62471.
(xvi) Free replacement warranties of 5 years for technical defects.

6.15.3 Applicable codes & standards

(a) 2006 / 95 / EC, Low Voltage Directive (LVD).
(b) 2004 / 108 / EC, EMC Directive.
(c) IS 1944 (Part 1 & 2): 1970 / Code of Practice for Lighting of Public Thoroughfares.
(d) EN 50530, IEC 62124, IEC 61347-2-13, IEC 62384, CISPR 15, IEC 61547, IEC 60598

6.15.4 Tests

Contractor shall submit all following test reports for LED lighting fixtures before dispatching of material to the site. All tests shall be carried as per IES-approved methods defined (LM-82)
(a) LM-80 for measurement of lumen of LED source.
(b) LM-79 for fixture - Electrical & Photometric measurement.
(c) TM-21 test for LED life.
(d) Thermal Characteristic- Test for Lumen output temperature dependency.
(e) Electrical Characteristic - Test for the calculation of efficacy.
(f) Driver testing for Power factor, THD & Isolation.
(g) IP Protection test against ingress of duct & solid objects for both indoor & outdoor LED fixtures.

6.15.5 Earthing

(i) Each luminaire shall be provided with an earthing terminal suitable for connection to the earthing conductor of 12 SWG GI wire.
(ii) Where a separate control gearbox is provided for housing the accessories, it shall be equipped with an earthing terminal suitable for connecting the earthing conductor of 12 SWG GI wire.
(iii) All metal or metal-enclosed parts of the luminaire/control gear box shall be bonded and connected to the earthing terminal to ensure satisfactory earthing continuity.

<u>Painting / Finish</u>

(i) All surfaces of the Luminaire / Control gear box housing accessories shall be thoroughly cleaned and degreased. It shall be free from scale, rust, sharp edges and burrs.
(ii) When an enamel finish is specified, it shall have a minimum thickness of 2 mils for the outside surface and 1.5 mils for the inside surface. The finish shall be non-porous and free from blemishes, blisters, and fading.
(iii) The luminaire housing shall be stove-enamelled, epoxy stove-enamelled, vitreous enamelled, or anodized, as indicated under various types of fittings.
(iv) The surface shall be scratch resistant and shall show no sign of cracking or flaking when bent through 90 deg over 1/2" dia mandrel.

(v) The finish of the luminaire shall be such that no bright spots are produced either by direct light source or by reflection. External control gear box provided for housing accessories shall be painted or galvanized.

Applicable Standards

All light fittings shall be energy-efficient type, with the lumen per watt specified. The design, manufacture, and performance of equipment shall conform to the latest standards specified below:

National Lighting Code	: SP 72
National Building Code	: SP 7 - 2016
National Electric Code	: SP 30 - 2023
Code of practice for industrial lighting	: IS 6665
Code of Practice for Interior Illumination	: IS 3646
2006 / 95 / EC, Low Voltage Directive (LVD).	
2004 / 108 / EC, EMC Directive.	
Code of practice for lighting of public thoroughfare	: IS 1944 (Part 1& 2)
Light and lighting. Lighting of workplaces	: BS EN 12464 part 1
Indoor workplaces	
Light and lighting. Lighting of workplaces	: BS EN 12464 part 2
Outdoor workplaces	

EN 50530, IEC 62124, IEC 61347-2-13, IEC 62384, CISPR 15, IEC 61547, IEC 60598

Electrical lighting fittings general and safety requirements	:	IS:1913 / BS:4533
Calculation of co-efficient of utilization	:	IS:3646 (Part - III)
Industrial lighting fittings with metal Reflectors	:	IS:1777
Decorative lighting outfits	:	IS:5077
Dust proof electric lighting fittings	:	IS:4012
Dust tight electric lighting fittings	:	IS:4013
Flood lights	:	IS:10322/BS:4533
Luminaires for street lighting	:	IS:10322 Part 5
Watertight electric lighting fittings	:	IS:3553 / BS:4533,5225(I)
Bayonet lamp holders	:	IS:1258 / BSEN 61184/IEC:60061
Edison screw lamp holders	:	IS:10276 / BSEN 60238
Bi-Pin lamp holders for tubular fluorescent lamps	:	IS:3323
Starters for fluorescent lamp	:	IS:2215 / BSEN 60155
Holders for starters for tubular fluorescent lamps	:	IS:3324 / BSEN 60400
Ballast for use in fluorescent lighting fittings	:	IS:1534 (Part 1) / BSEN 60920& 60921
Transistorized ballast for fluorescent lamps	:	IS:7027
Ballast for HP mercury vapour lamp	:	IS:6616
Capacitors for use in fluorescent lamps	:	IS:1569 / BSEN 61048
HPMV & LP sodium vapour discharge circuits		& 61049 / IEC:60586
Vitreous enamel reflector for tungsten filament lamp	:	IS:8017
Tubular fluorescent lamps	:	IS:2418 (Part –1) / BSEN 60081 IEC:60081
High pressure mercury vapour lamps	:	IS:9900 / BS:3677 / IEC:60188
Tungsten filament General Electric lamps	:	IS:418 / IEC:60432
Cast acrylic sheets for use in Luminaires	:	IS:7569
Screwless terminal and electrical	:	IS:10322

connections for lighting fittings		
High pressure sodium vapour lamps	:	IS:9974
Emergency lighting units	:	IS:9583
Ignition proof enclosures, dust-tight for elect Equipment	:	IS:11005
Luminaires	:	IS:10322 (Part I to V)

6.15.6 Lighting System Equipment

Arrangement for busbars, main connections and auxiliary wiring and marking	:	IS:5578 / 11353 / BS:159
Enclosed distribution fuse boards and Cut-outs for voltages not exceeding 1000V	:	IS:2675 / BSEN 61439
General requirements for switchgear and Control gear for voltages not exceeding 1000 V	:	IS/IEC:60947
Code of practice - installation and	:	IS:10118 / BS:6423
Maintenance of switchgear	:	BS 6626, BS 6867
Factory built assemblies of switchgear and control gear for voltages up to and Including1000 V AC and 1200 V DC	:	IS/IEC 61439 / BS-5486 / IEC:61439
Miniature air break circuit breakers for AC circuits	:	IS:8828 / BSEN 60898
HRC cartridge fuse links up to 650 V	:	IS:9224 / BS:88 / IEC:60269
Instrument transformers	:	IS 16227 / IEC 61869 / IS/IEC 60044
Direct acting electrical indicating Instruments	:	IS:1248 / BS:89 / IEC:60051
AC electricity meters	:	IS:722 / BS 5685
Electrical relays for power system protection	:	IS:3231 / BS:142 / IEC:60255
Switches for domestic and similar purposes	:	IS:3854 / BS:3676
Three pin plugs and socket outlets	:	IS:1293 / BS:546
Boxes for enclosure of electrical accessories	:	IS:5133(1)
Rigid steel conduits for electrical wiring	:	IS:9537 / BS:31
Accessories for rigid steel conduits for electrical wiring	:	IS:3837 / BS-31
Flexible steel conduits for electrical wiring	:	IS:3480
Rigid non-metallic conduits for electrical Installations	:	IS:9537 / BS:4607(2)
Fittings for rigid non-metallic conduits	:	IS:3419 / BS:4607(2)
PVC insulated cables for working voltages Up to and including 1100 V	:	IS:694
Tubular steel poles	:	IS:2713
Specification for copper rods and bars	:	IS:613
Code of practice for phosphate coated iron and steel	:	IS:6005 / BS:3189
Fittings for rigid steel conduits for electrical wiring	:	IS:2667

6.15.7 Lighting Fixtures (Luminaires-LED)

(a) Luminaires shall be designed for continuous trouble-free operation without reduction in lamp life or without deterioration of materials and internal wiring. Outdoor fittings shall be weatherproof and rainproof in type.
(b) The Luminaires shall be designed so as to facilitate easy maintenance, including cleaning, replacement of lamps/starters etc.
(c) Connections between different components shall be made in such a way that they shall not work loose by small vibration.
(d) For each type of Luminaire, the Contractor shall furnish utilisation factor tables to indicate the proportion of the light emitted by the bare lamps that falls on the working plane.
(e) All Luminaires shall be supplied complete with lamps suitable for operation on a supply voltage with the variation in supply voltage, frequency and combined voltage and frequency of ± 10%, ± 5% and ± 10% respectively.

Decorative Luminaires (Luminaires-LED)

(a) These luminaires shall be generally indoor type provided with cold rolled cold annealed (CRCA) sheet steel channel/rail cum reflector housing complete with all electrical control accessories mounted on it. The finish shall be stove enamelled.
(b) Decorative LED type luminaires shall be either open type, provided with translucent white opal acrylic diffusers, polystyrene lens prismatic or square polystyrene louvers
(c) Luminaires shall be suitable for the number of lamps of the specified wattage, and shall be suitable for direct mounting on a ceiling, wall, or column, or for pendant or recess mounting in a false ceiling.
(d) Decorative luminaires with mirror optic reflectors shall be of the wide-angle dispersion type. Where these luminaires are mounted in control rooms and computer rooms, clip-on type adjustable reflectors, which can be attached to the tube, shall be provided to direct the light output in the desired direction. This shall be mainly to reduce reflection of the light source from TV / monitor screens.
(e) Luminaires mounted recessed in false ceiling shall be with reflector housing and a spring-loaded fixing arrangement for the diffuser/louver frame. It shall be possible to have access to the lamp and other accessories from below.

Industrial Luminaires (Luminaires-LED)

(a) The luminaire shall be provided with a CRCA sheet steel mounting rail, complete with a reflector of a minimum 20 SWG thickness, and all control accessories mounted on it. The finish shall be vitreous enamelled.
(b) Luminaires shall be suitable for the number of lamps of specified wattage, direct mounting on ceiling/wall / column / pendent mounting.
(c) The distribution of light shall be such that at least 80% of the total luminous flux from the luminaire shall be in the lower hemisphere.
(d) The luminous output of the luminaire with reflector shall not be less than 75% irrespective of type of reflector used

Bulkhead LED Luminaire

(a) The luminaire shall be of robust construction, with a cast aluminium or vitreous enamelled housing, a heat- and shock-resistant prismatic or clear glass cover, and fixed with neoprene gaskets for sealing. For mechanical protection to the glass cover, round steel wire guard with vitreous enamelled finish shall be provided
(b) The luminaire shall be suitable for direct mounting to ceiling / wall / column and used for general purpose indoor lighting.

High, Medium and Low Bay LED Luminaires

(a) High and medium bay luminaires shall be equipped with a cast aluminium housing, an anodized aluminium mirror-polished reflector canopy featuring an eye bolt for suspension, cooling fins, and a glass cover.
(b) The luminaire shall be suitable for up to 400 / 1000 watts LED lamps. The control gear accessories shall be mounted integral with the luminaire.
(c) High bay luminaires shall be used when the mounting height is above 8 meters, while medium bay luminaires shall be used when the mounting height is between 6 and 8 meters.

Flood Light LED Luminaire

Flood light luminaires shall be of weatherproof construction with cast aluminium housing, anodized aluminium mirror polished reflector, heat resistant, toughened glass cover and necessary neoprene gaskets to prevent ingress of dust

(a) The housing shall be supported on a cast iron base and capable of being swivelled in both horizontal and vertical directions and locked in any desired position.
(b) For focusing purposes, knobs, shall be provided along with sector plate indicating the angle in degrees between 0 and 90 deg in vertical direction.

Outdoor Lantern LED Luminaires

(a) Post top lantern Luminaires shall be generally outdoor weatherproof type for illumination of walkways, gate posts, gardens etc
(b) The luminaire shall have a cast aluminium spigot of 50 / 60 diameter finished with corrosion-proof paint for mounting, an opal acrylic or high-density polyethylene (HDPE) diffuser bowl, complete with an integral mounted control gear, neoprene gaskets, an earthing terminal, etc.

Sub-station Lantern

(a) Sub-station lantern shall be generally outdoor weatherproof type for illumination of switchyard equipment.
(b) The luminaire shall have cast aluminium housing finished with corrosion proof paint, spigot for mounting on pole, prismatic glass refractor dome to give distribution of light in horizontal plane, anodized aluminium reflector to give light distribution at an angle 20 to 40 degrees, above the horizontal plane, complete with integral mounted control gear, neoprene gaskets, earthing terminal etc.

Street Lighting Luminaires

(a) Street lighting LED luminaire shall be outdoor weatherproof type for illumination of secondary roads, walkways, peripheral lighting of buildings etc.
(b) The luminaire shall be of semi-cut-off or non-cut-off type, with a CRCA sheet steel housing, a vitreous enamelled, plain, or corrugated clear acrylic cover, complete with integral mounted control gear, neoprene gaskets, and either a side pipe entry or top suspension type.
(c) The luminaire shall be of semi-cut off with cast aluminium housing, acrylic or prismatic cover, polished aluminium reflectors, complete with integral mounted control gear, neoprene gaskets and with rear pipe entry.
(d) The Contractor shall provide street lighting systems to illuminate all site roadways within the treatment facility areas and access road. Lux level for outdoor site shall be as per IS 1944. Outdoor lighting shall cover the perimeter portion also to focus CCTV camera at 20 Lux level.
(e) The lanterns shall incorporate LED lamps with integral lamp control gear, and weather-proof body.
(f) The poles shall be sited a minimum of 1m from the road kerb edge with non-extended brackets to locate the lanterns at the kerb.
(g) The street lighting shall be fed by independent radial buried cable circuits, controlled and fed from a street lighting switchboard. The cables laid for outdoor lighting application shall be wire armoured.

(h) Each circuit shall be contactor switched, controlled by an astronomical timer, and a manual-auto control selector switch. The contactor, time switch and manual control switch for each area shall be incorporated in the LV road lighting distribution switchboard.

Portable Emergency Light Luminaire

(a) The emergency light of the installed luminaire shall be the indoor type to provide emergency light during failure of the normal AC supply.

(b) The luminaire shall be with CRCA sheet steel enclosure, complete with metalized mirror reflector, leak proof re-chargeable battery rated for two-hour discharge, battery charger, charger-on lamp, push button switches, automatic changeover switch/relay, two meter length cord with plug, mounting pads and other accessories required for satisfactory operation of the luminaire.

(c) The luminaire shall be suitable for connection to a 240 V, 50 Hz single-phase supply. On failure of normal AC supply the luminaire shall pick-up automatically and on restoration of AC supply the luminaire shall switch off automatically.

(d) The luminaire shall be suitable for energy efficiency LED lamps.

6.15.8 Accessories for Luminaires

Reflectors

(a) The reflectors shall be made of CRCA sheet steel / aluminium / silvered glass / chromium plated sheet copper as indicated for the above-mentioned luminaires.

(b) The thickness of steel/aluminium shall comply with relevant standards. Reflectors made of steel shall have vitreous enamelled finish. Aluminium used for reflectors shall be anodized / epoxy stove enamelled / mirror polished. The finish for the reflector shall be as indicated for the above-mentioned fittings.

(c) Reflectors shall be free from scratches or blisters and shall have a smooth, glossy surface with an optimum light-reflecting coefficient to ensure the overall light output specified by the Contractor.

(d) Reflectors shall be readily removable from the housing for cleaning and maintenance, without disturbing the lamps or requiring the use of tools. They shall be securely fixed to the housing by means of positive fastening device of captive type.

Lamp holders / Starter Holders

(a) Lamp holders shall have low contact resistance, shall be resistant to wear, and shall be suitable for operation at the specified temperature without deterioration in insulation value. They shall hold the lamps in position under normal conditions of shock and vibration encountered under normal installation and use.

(b) Lamp holders for the fluorescent lamps shall be of the spring-loaded bi-pin rotor type. Live parts of the lamp's holder shall not be exposed during insertion or removal of lamp or after the lamp has been taken out. The lamp holder contacts shall provide adequate pressure on the lamp cap pins when the lamp shall be in working position.

(c) Lamp holders for induction, mercury vapour and sodium vapour lamps shall be of Edison Screw (ES) type.

(d) The starter holders shall be designed to be mechanically robust and free from operational difficulties. They shall be capable of withstanding the shocks encountered within normal transit, installation, and use.

Control switch gear electronic ballasts

(a) The ballasts shall be designed to have a long service life and low power loss. The ballasts shall be of the inductive, heavy-duty type, with copper wire wound, filled with a thermosetting, insulating, moisture-repellent polyester compound, and filled under pressure or vacuum. Ballasts shall be provided with taps to set the voltage within the range of variation in supply voltage of ± 10% of 240 V End connections and taps shall be brought out to a suitable terminal block rigidly

fixed to the ballast enclosure. Ballasts shall be free from hum, and the Contractor shall replace any ballasts that produce hum at no cost.

(b) Ballasts shall be mounted using self-locking, anti-vibration fixings and shall be easily removable without requiring the removal of the fittings. They shall be in dust-tight, non-combustible enclosures.

(c) Separate ballast for each lamp shall be provided in the case of multi-lamp luminaires, except for 2 x 20W luminaires.

Starters / Igniters

(a) Starters shall have bimetal electrodes / electronic igniters and high mechanical strength. Starters shall be replaceable without disturbing the reflector or lamps and without the use of any tool. Starters shall have brass contacts and radio interference capacitors.

Capacitors

(a) The capacitors shall have a constant value of capacitance and shall be connected across the supply of individual lamp circuits.

(b) The capacitors shall be suitable for operation at specified supply voltage conditions and shall have a value of capacitance so as to correct the power factor of their corresponding lamps circuit to the extent of 0.98 lag or better.

(c) The capacitors shall be hermetically sealed preferably in a metal enclosure to prevent seepage of impregnate and ingress of moisture.

6.15.9 Galvanized Octagonal Poles for Street Lighting

The Octagonal poles shall be designed to withstand the maximum wind speed of 169 KM / Hr. as per IS 875. The top loading, i.e., the area and weight of fixtures, are to be considered when calculating the maximum deflection of the pole, and it shall meet the requirements of BS 5649 Part VI.

(a) Pole Shaft

The pole shaft shall have an octagonal cross-section and shall be continuously tapered with single longitudinal welding. There shall not be any circumferential welding. The welding of the pole shaft shall be performed using the Submerged Arc Welding (SAW) process.

All octagonal pole shafts shall be provided with a rigid flange plate of suitable thickness with provision for fixing 4 foundation bolts. This base plate shall be fillet welded to the pole shaft at two locations i.e., from inside and outside. The welding shall be done as per a qualified Manual Metal Arc Welding (MMAW) process approved by a third-party inspection agency.

(b) Door opening

The octagonal poles shall have door of approximate 500 mm length at the elevation of 500 mm from the Base plate. The door shall be vandal-resistant and shall be weatherproof to ensure the safety of inside connections. The door shall be flush with the exterior surface and shall have suitable locking arrangement. There shall also be suitable arrangement for the purpose of earthing.

The pole shall be adequately strengthened at the location of the door to compensate for the loss in section.

(c) Material

Octagonal Poles	:	HT Steel Conforming to grade S355JO
Base Plate	:	Fe 410 conforming to IS 226 / IS 2062
Foundation Bolts	:	EN8 grade

(d) Welding

The welding shall be carried out in accordance with approved procedures, duly qualified by a third-party inspection agency. The welders shall also be qualified for welding the octagonal shafts.

(e) Pole sections

The Octagonal Poles shall be in single section (up to 11 mtr) There shall not be any circumferential weld joint.

(f) Galvanization

The poles shall be hot dip galvanized as per IS 2629 / IS 2633 / IS 4759 standards with an average coating thickness of 100 microns. The galvanizing shall be done in a single dipping.

(g) Xing type

The Octagonal Poles shall be bolted on a pre-cast foundation with a set of four foundation bolts for greater rigidity.

(h) Top Mountings

The galvanized mounting bracket shall be supplied along with the Octagonal Poles for the Installation of the luminaries.

(i) Manufacturing

The pole manufacturing and galvanizing unit shall be ISO 9001:2000 and ISO 14001 certified to ensure consistent quality and environmental protection.

(j) Service window

A service window, measuring 150 mm x 100 mm, shall be provided in the base of the pole to allow access to electrical connections and terminations. It shall be covered with GI (Galvanized Iron) plate and proper rubber gaskets shall be provided to prevent any ingress of water etc.

(k) Electrical connections

Four-way connectors shall be provided along with Slide lock and 1 no. 6 amps SP MCB including 2.5 sq.mm PVC insulated copper conductor wires from the terminal block to the fixture and 2 nos. 32 mm dia. GI sleeves of suitable length shall be provided up to the service window. An earth boss shall be provided on the control plate along with connectors and interrupters.

(l) Tower Ladder for Maintenance

A tower ladder for streetlight fixture and bracket maintenance shall be provided and shall always be available at the site. The ladder shall have an extended platform, a tool tray, and two Tie-rod for extra stability of the ladder. It shall be possible to have smooth operation to extend the ladder to the required height and easy extension with easy, smooth hand operation employing the winch and wheel mechanism. Bottom shall be provided with MS base trolley fixed with heavy solid rubber wheels along with jack rods.

6.15.10 Drawings and Data

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, test certificates etc shall be submitted along with the bid / after award of contract as specified under “Bid / Contract Drawings”, Part 3, General Requirements, Volume - 2 of Bid Documents.

6.15.11 Lighting System Equipment

Main Lighting Distribution Board and Lighting Panels (AC Phase segregated & DC)

(a) Constructional Features

(i) Boards and panels shall be sheet steel enclosed and shall be fully dust and vermin proof, providing a degree of protection of IP 52 for indoor. Outdoor panels shall, in addition, be completely weather-proof with a sloping canopy for protection against rain and provide a degree of protection of IP 55. The sheet steel used for frame, frame enclosures, doors, covers and partitions shall be cold rolled 2 mm thick.

(ii) All boards and panels shall be provided with hinged doors for access to equipment. Doors shall be gasketed all round with neoprene gaskets. For the main floor-mounted distribution boards with the MCB arranged in tier formation, the hinged door of each unit shall be interlocked to prevent the door from opening when the switch is ON and to prevent the switch from closing with the door not fully closed. However, a device for by-passing the door interlock shall be provided to enable the operation of the switch with the door open, when necessary, for examination/maintenance. For wall mounting 1-phase ways lighting panels when provided with MCBs, a hinged, latched front door shall be provided with key-locking facility and a slotted Bakelite sheet shall be provided inside. Only the MCBs operating knobs or the fuse cap covers shall project out of the Bakelite sheet slots for safe operation and neat appearance Incomer to lighting panels shall be provided with TPN MCCB with RCD (30 mA sensitivity)

(iii) All accessible live connections/metals shall be shrouded, and it shall be possible to change individual fuses, switches, MCBs from the front of the boards/panels without danger of contact with live metal.

(iv) For floor mounting type distribution boards, adequately sized mounting channels shall be supplied and for wall/column / structure mounting type panels suitable mounting straps shall be provided.

(v) Adequate interior cabling space and suitable removable cable entry plates shall be provided for top entry of cables through glands and or conduits as required. Necessary number of glands to suit the specified cable sizes shall be provided. Cable glands shall be screwed on type and made of brass.

(vi) Two earthing terminals shall be provided to suit the earthing conductor

(vii) All sheet steel parts shall undergo rust-proofing process which should include degreasing, de-scaling and a recognized phosphate process. The steel works shall then be painted with two coats of Zinc - chromate primer and two coats of final stove-enamelled finish paint of specified colour.

(b) Busbars

(i) Busbars shall be of copper conductor of hard drawn (HD) and high conductivity. All bus bars shall be insulated with a close-fitting sleeve of hard, smooth, dust and dirt-free, heat-shrunk PVC insulation of high dielectric strength, to provide a permanent, non-ageing, and non-tracking protection, impervious to water, tropical conditions, and fungi.

(ii) Busbars shall be provided with at least the minimum clearances in air as per applicable standards for a 500 V, 3-phase system.

(iii) Busbars shall be adequately sized for the continuous current rating such that the maximum temperature of the busbars, busbar risers/droppers, and contacts does not exceed 85 °C under site reference ambient temperature.

(iv) The busbars, busbar connections, and busbar support shall have sufficient strength to withstand thermal and electro-mechanical stresses of the fuse / MCB's let-through / cut-off current associated with the specified short-circuit level of the system.

(v) Busbar supports shall be made from suitable insulating material such as Hylam sheets, glass reinforced moulded plastic materials, permali wood or cast resin. Separate supports shall be provided for each phase of the busbars. If a common support shall be provided for all three phases, anti-tracking barriers shall be incorporated.

(vi) The neutral bus of the main 3-phase, 4-wire distribution board shall be rated not less than 50% of the phase busbars. The neutral bus of the 1-phase way lighting panel shall be rated the same as the phase busbars. The neutral bus should have sufficient terminals and detachable links for full number of single-phase outgoing lighting circuits.

Panels / Boards' Component Equipment

(a) Miniature Circuit Breakers (MCB) / RCD

(i) MCBs shall be hand-operated, air break, quick make, quick break type conforming to applicable standards

(ii) A fuse shall protect the switch, and the MCB shall be provided with an overload / short-circuit protective device for protection under overload and short-circuit conditions. The minimum breaking capacity of MCBs shall be 10 kA RMS at 415 V / 220 V DC.

(iii) The switch shall have a provision for locking in both fully open and closed positions. MCBs shall be provided with locking facility

(iv) The incomer shall be MCCB for ≥ 63A and shall be MCB TPN for < 63A connections shall be phase segregated shall be insulated and all live connections shall be shrouded RCD with suitable rating shall be provided for incomer 100mA and power receptacle feeder 30mA One digital type energy meter shall be provided on each lighting MCB DB.

(b) Fuses for DC

(i) Fuseless system shall be preferable; however, some special case fuses can be used. Fuses generally shall be of the HRC cartridge fuse-link type having a certified rupturing capacity of 80kA at 440V. Fuses up to 63A for distribution systems of medium short circuit levels may be of HRC link type, having a certified rupturing capacity of not less than 46kA at 440V and 16kA at 250V DC.

(ii) Fuses shall be provided with visible indication to show that they have operated.

(iii) Insulated fuse pulling handle shall be provided for each size of fuse for each switchboard.

(c) Indicating Instruments and Meters (Digital)

(i) Whenever required, digital instruments and meters shall be of the flush mounting type They shall be suitably mounted so as to provide for easy access to CTs and small wiring.

(ii) Instruments such as voltmeter and ammeter shall be of digital instruments.

(iii) Watt-hour meters shall be of direct reading of digital multifunction meter.

(d) Instrument Transformers

(i) Current and voltage transformers shall be of the dry type, of metering accuracy class 10 Unless otherwise specified, it shall be the responsibility of the Contractor to ensure that the VA burden of the instrument transformer shall be adequate for the meters connected to it.

(ii) Test links shall be provided in both secondary leads of the CTs to easily carry out current and phase angle measurement tests. Facilities shall be provided for short-circuiting and grounding the CTs at the terminal blocks.

(iii) Voltage transformers shall be provided with suitably rated primary and secondary fuses.

(e) Indicating Lights

Indicating lights shall be of the clustered LED type with translucent covers

(f) Internal Wiring.

(i) Panels / boards shall be supplied completely wired, ready for the external connections at the terminal blocks. Wiring shall be carried out using 650/1100V grade, PVC-insulated, stranded copper conductors of adequate size, suitable for the rated circuit current.

(ii) Engraved identification ferrules marked to correspond with the wiring diagram shall be fitted at both ends of each wire.

(iii) All wiring shall be terminated on terminal blocks. Terminal blocks shall be one-piece moulded rated 500 V of reputed make, preferably stud type for higher current ratings, such that wires are connected by cable-lugs and complete with nuts and washers. Terminals shall be adequately rated for the circuit current; the minimum rating shall be 20A.

(iv) Terminals for circuits with voltage exceeding 125V shall be shrouded.

(v) Terminals shall be numbered and provided with an identification strip for identification of the circuit.

(vi) Terminal blocks for CT secondary lead wires shall be provided with shorting and disconnecting / earthing facilities.

Labels & Diagram Plate

(a) All door-mounted equipment, as well as equipment mounted inside the switchboard/panels, shall be provided with individual labels with equipment designation/rating. Additionally, the boards/panels shall be labeled on the front with the designation of the board/panel.

(b) Labels shall be made of non-rusting metal, 3-ply laminoid or engraved PVC.

(c) Inside the door of the 1 phase ways lighting panels a circuit diagram/description shall be fixed for reference and identification.

Light Control box and switches

(a) Light control switches of ratings and types, i.e., decorative/industrial, shall be supplied as required. The switches shall be Modular, suitable for use on a 240V, 1Ph, 50Hz supply.

(b) Switches shall be of flush type for mounting behind an insulated modular plate or incorporated with a switch plate for mounting flush with the surface of a wall or suitable enclosure. The modular switch box/enclosure may be recessed into or mounted on a wall as per the requirement of project layouts.

(c) The size of enclosure modular boxes shall be chosen to accommodate the number of switches to be installed at the particular location. The enclosures shall be made of 18-gauge galvanized sheet steel. The enclosure plates or boxes shall be fabricated from quality-tested raw materials, such as metal, PVC, or powder-coated metal. An enclosure intended for surface mounting shall not have holes or gaps in its sides other than those expressly provided for cable entry.

Receptacle Units

(a) Receptacle units shall consist of a socket outlet with an associated switch and plug. The socket outlet and switch (5/6A) or MCB (15/16A) shall be flush-mounted within a galvanized 18-gauge steel or modular enclosure with an insulation cover. The box may be recessed into or mounted on a wall, as per the project layout requirements.

(b) The receptacle units shall be suitable for 240V, 1ph - N, 50Hz, 5 / 6A / 415V, 3Ph – N, 50Hz, 15 / 16A supply as required.

(c) Single-phase receptacles rated 15 / 16A shall be associated with an RCCB and MCB of the same current rating, and the receptacle shall become live only when the associated RCCB and MCB are in the “ON” position.

(d) Three-phase receptacles shall be metal-clad associated with a TPN MCB housed in the same enclosure. The receptacle shall become live only when the associated MCB switch shall be in “ON” position.

(e) The plugs shall be provided along with three phase receptacle with cord grips to prevent strain and damage to conductors / wires at connection and entry points.

Lighting Wires

(a) The wires for wiring in lighting system shall be 1100-volt grade ISI make, 1/C, PVC insulated, un-armoured with stranded copper conductors.

(b) The minimum area of conductors shall be 15 sq.mm for light fittings and 5/6A Receptacles and 25 sq.mm for receptacles rated 15 / 16 A and above.

(c) The wires shall be coded white for phase/positive of DC and black for neutral / negative of DC.

Conduits

(a) Rigid non-metallic conduits and their associated fittings as required shall conform to applicable standards. The minimum size of conduit shall be 20 mm for surface installation and 25 mm for concealed installation.
(b) Non-metallic conduits shall be supplied in standard lengths of 5 m of 25 mm thickness and shall conform to IS 2509.
(c) Supply of conduits shall include all associated fittings like couplers, bends and tees as required for lighting system installation work inclusive of all the consumables such as adhesive, rawl plug, screws etc.

Junction Boxes

(a) Square or rectangular type modular Junction boxes with terminals shall be supplied for branching and terminating lighting cables when required for indoor/outdoor areas, 3-phase receptacles, etc.
(b) The junction boxes shall be dust and vermin-proof and shall be fabricated from quality-tested raw material such as metal, PVC, and powder-coated metal and shall be complete with a removable cover plate with gaskets. Boxes shall be additionally weatherproof with earthing terminals.
(c) The boxes shall have provision for wall, column, pole, or structure mounting and shall be provided with cable/conduit entry knockouts, terminal blocks, and earthing terminals as required.
(d) The terminal blocks, with a specified number of terminals, shall be mounted securely on brackets welded to the back sheet of the box. The terminals shall be 600 V, grade, one-piece construction, complete with terminals, insulation barriers, galvanized nuts, bolts, and washers, and provided with identification strips of PVC. The terminals shall be made of copper alloy and shall be of box clamp type.
(e) The boxes shall be aesthetically pleasing and weatherproof for an outdoor unit with an MCB for branching lighting circuits.

6.15.12 Drawings and Data

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, test certificates etc shall be submitted along with the bid / after award of contract as specified under “Bid / Contract Drawings”, Part 3, General Requirements, Volume - 2 of Bid Documents.

6.16 Earthing and Lighting Protection System

6.16.1 General

The earthing and lightning protection system covers earthing conductors, earth electrodes and accessories.

- The metallic frame of all electrical equipment shall be earthed by two separate and distinct connections to the earthing system.
- Crane rails, tracks, metal pipes, and conduits shall also be earthed at two points.
- Steel RCC Columns, metallic stairs and rails of the building housing electrical equipment, also shall be connected to the nearby earthing grid conductor.
- Metallic sheaths/screens and armour of multicore cables shall be earthed at both ends.
- Metallic sheaths and armour of single-core cables shall be earthed at the switchgear end only.
- Every alternate post of the switchyard fence shall be connected to the earth grid by a GS flat and gates by a flexible lead to the earthed post.

- Each Continuous length of cable tray shall be earthed at a minimum of two points by GS Flats to the earthing system; the distance between the earthing points shall not exceed 20m.

- Lightning Protection System shall compromise vertical/horizontal air termination rod/strip, air termination support system, down conductors, down conductor holders, test links, counters, and earth electrodes with chambers. Air terminations, down conductors and test links shall be of galvanized steel conductors and earth connection below the ground level shall be of mild steel. Lightning Protection System down conductors shall not be connected to other earthing conductors above the ground level.

6.16.2 Applicable Standards

The earthing and lightning protection system shall conform to the National Electrical Code, National Building Code, CEA Regulations, and the latest applicable standards indicated below:

Code of Practice for Earthing	:	IS:3043-2018
Manual on Earthing of AC Power System	:	CBIP 302
Code of Practice for the Protection of Building and allied structure against lightning	:	IS/IEC: 62305-1 to 4
Hot dip galvanizing	:	IS:2629, 2633, 4759
Structural steel	:	IS:2062 & 808
Welding	:	IS:816

6.16.3 Earthing System

The electrical installation shall be required to be connected to the general mass of the earth by an earthing conductor. The material used for the earthing conductor shall be as follows:

(a) Conductors above ground level and in trenches: galvanised steel (GS) flat
(b) Conductor buried in the ground or embedded in concrete: mild steel (MS) flat.
(c) Pipe Electrode: Cast Iron or Galvanized Iron
(d) Rod Electrodes: Mild Steel
(e) Lightning protection air termination and down conductors for buildings: Galvanized Steel (GS)

Allowance shall be made for a reduction in the cross-sectional area of the steel over the design life of the earthing system.

Conductor sizes for burial in the earth shall be calculated with the indicated corrosion allowances as per IS 3043:2018. The minimum thickness shall be considered as 6mm.

The earth electrode system shall comprise one or more earth electrodes, an earthing network, a mesh, or a combination of these to obtain the required earth electrode resistance.

Earth electrodes used shall be of heavy-duty GI pipe of not less than 40mm NB and 4150mm long. Where multiple electrodes are used, they shall be separated by a distance of not less than the driven length.

Each earth electrode pipe shall be welded at the top to a mild steel plate to which the earthing tapes shall be connected. These connections shall each be housed in individual concrete inspection chamber set flush to the finished ground level and shall allow disconnection for testing of individual electrodes. The chamber shall be permanently marked ‘Electrical Earth’.

All materials used for the earth electrode installation shall be purpose-made for the application and site conditions and shall be approved by the Employer's Representative.

Unless otherwise stated all excavation for the installation of the earth electrodes and the inspection pit shall be carried out by the Contractor.

After the earth installation has been completed, the Contractor shall demonstrate to the Employer's Representative that the resistance of the electrodes to earth and the continuity of the earth network are within the limits specified. Any additional earth electrodes and test instruments required for the tests shall be provided by the Contractor.

Marker posts and plates shall be provided to mark the route of buried tape or conductor electrodes. The markers shall be similar to those provided for cable routes.

Two earthing leads shall be used for voltage of the equipment above 250V and for rated voltage of 250V and below, one earth lead shall be provided.

Earth conductors laid in soil in the form of closed grid for the main plant area which covers transformer yard, substation building and all other individual buildings.

Transformer & DG neutrals. Lightning arrestors, capacitor banks, surge arrestors, 24 DC system, UPS, each downcomer of lightning protection system shall be directly connected to independent earth electrodes. Earth leads of DG & transformer shall be connected to TWO separate treated earth pits by TWO separate earth leads starting from neutral bushing. Any specific requirement of local authority regarding type of electrode shall be met with.

Main earthing conductors shall be buried in earth around each building at a minimum depth of 600mm at a distance of 1500mm from outer boundary of the building.

The earth grid of different areas shall be interconnected through test pits to the main plant area earth grid to enable measurement of ground resistance of each area separately.

Minimum two tap offs from main earthing loop outside the building shall be taken inside the building and connected to the earthing conductor embedded in floor slab with approximately 50mm cover or to the earthing conductor in cable trench.

Tap off from the main earth grid shall be taken with earth riser of 500mm length above ground level for outdoor and 200mm length for risers inside the building.

Separate floor earth grids shall be formed and interconnected for multi-storey buildings.

Earth pit construction shall be as per IS 3043-2018. Soil enhancements with bentonite solutions tested by CPRI shall be provided to absorb and retain moisture in the soil for longer periods to maintain the soil's conductivity.

6.16.4 Lightning Protection System

(i) The need of lightning protection has been established by calculating the overall risk factor as per IS / IEC 62305 series.

(ii) Air termination system comprising of rods/mesh or combination of both shall be provided and the methods used to determine the positioning of Air termination system shall be as per IS/IEC 62305.

(iii) Air termination system shall be connected to the earthing system by down conductors fixed along the outer surface of building Number & layout of the down conductors shall be as per IS / IEC 62305.

(iv) Each down comer shall be terminated to a separate treated test earth electrode which in turn shall be connected to station earthing system.

(v) The link shall be provided in the run of each down conductor at approximately 1000 mm above ground level.

(vi) The lightning protection air termination network shall be fixed in such a way that they remain in their installed position even during severe weather conditions. The necessary accessories such as cleats, clamps, welding materials, bolts, nuts shall be provided.

(vii) Air termination system shall be connected to the earthing system below ground by down conductors.

(viii) All joints in the down conductors shall be of welded / brazed type.

(ix) The lightning protection system shall not be in direct contact with underground metallic service ducts, cables, cable conduits and metallic enclosures of electrical equipment.

6.16.5 Main Equipotential Bonding Conductor

Main equipotential bonding conductors shall be provided to connect the earth electrode system to conductive parts forming the works.

Equipotential bonding conductors shall have the following **minimum sizes** as per Cl. No. 6.17.3 & 6.17.4. Actual equipotential bonding conductor size shall be calculated based on the fault conditions.

(a) Main Equipotential Conductors

- Main Earth Conductor buried in earth	65 x 10 mm MS flat
- Main Earth Conductor above ground	65 x 10 mm GS flat
- Transformers, main switchboard and standby generator installation	65 x 10 mm GS flat
- APFC Panel	65 x 10 mm GS flat
- interconnection to lightning protection system	50 x 10 mm GS flat
- interconnection to MCCs	50 x 10 mm/50 x 6 mm GS flat

(b) Equipotential Conductors

- interconnection to CPs	25 x 3 mm	GS flat
- local push buttons	14 SWG	GS wire
- lighting distribution board	4 SWG	GS wire
- lighting and receptacle system	12 SWG	GS wire
- outdoor street lighting	8 SWG	GS wire
- ladder rack and cable tray at suitable points	25 x 3 mm	GS flat
- handrails and metallic structures	25 x 3 mm	GS flat
- building reinforcement	25 x 3 mm	GS flat
- incoming and outgoing process services	25 x 3 mm	GS flat
- steel structures comprising storage tanks, mezzanine platform, crane rails, air handling ductwork systems etc.	25 x 3 mm	GS flat

(c) LV Motors

- up to 10 kW	8 SWG	GS wire
- 10 to 20 kW	4 SWG	GS wire
- 20 to 50 kW	25 x 3 mm	GS flat
- Above 50 kW	50 x 10 mm	GS flat

-	Earth electrode	min. 40mm dia. 4150 mm long heavy Duty GI pipe electrode as per IS 3043-2018

Notes:

1. Equipotential conductors shall interconnect between the device to be bonded and the main equipotential conductor.
2. Connections to building structural steelwork or concrete reinforcement shall be made by a bolted connection to a tag welded to the steelwork or reinforcement bars. Unless otherwise specified, at least two connections shall be made to the steelwork and reinforcement bars at the perimeter of each building at diagonally opposite locations.

6.16.6 Circuit Protective Conductors

An independent circuit protective conductor shall be provided for each circuit and may comprise one or any of the following as appropriate:

- a separate core within a multicore cable.
- a separate conductor installed within a conduit or trunking. Steel conduit or trunking shall not be used as a circuit protective conductor.
- the metal sheath of an armoured cable shall be bonded to the metalwork of the apparatus and to the apparatus earth bar, if any.
- the copper sheath of a mineral insulated copper sheathed cable.
- an independent earthing conductor MS or GS conductor run adjacent to the circuit it protects.

Circuit protective conductors associated with the main circuits supplying switchboards and large electrical loads, i.e., motors in excess of 75 kW shall form a separate core of a multicore cable feeding the device or shall be an independent insulated copper conductor run adjacent to the supply cable. The size of the circuit protective conductor shall be calculated in such a manner as not to take into consideration the contribution of any other parallel or fortuitous earth paths.

The armouring of the supply cable shall not form the sole means of earthing a switchboard or large electrical load.

Where the cable armouring or sheath shall be used as the circuit protective conductor it shall be securely bonded at both ends to the metalwork of the apparatus and to an earth bar. Particular care shall be taken to ensure continuity across items of apparatus situated within a cable run and should the design of such items of apparatus not give adequate and lasting continuity through its structural body then additional earthing clips and conductors shall be provided to independently bond the cable sheaths together. Similarly additional earthing clips shall be provided to bond the cable sheaths / armour to any piece of apparatus fitted with a special earth terminal should the earth connection for the termination gland be inadequate. Any additional earthing clips shall be fitted within the apparatus wherever possible.

6.16.7 Instrumentation Earth

An instrumentation earth bus, if required shall be provided in each control panel. This shall comprise a copper flat of cross section not less than 25 x 6 mm and length to suit the number of connections. It shall be mounted on at least two insulated supports and be provided with a single earth connection to the instrument plate type earth. If due to the physical size of a control panel more than one instrument earth bar shall be required, the additional bar shall be connected again with a single earth connection to the same point as before. In this fashion all instrument earths shall be connected radials from the same plate type earth point.

The earth pit for instrumentation system shall be separate. Electric earth pit shall not be used for earthing of instrumentation equipment. All signal cable screens (analogue and digital) shall be terminated onto

the instrument earth bar. Signal cable screens shall be earthed at the control panel end only. Screens at the field end shall be tied back and insulated. Connection between instrument earth bar and instrument plate type earth pit shall be insulated copper wire such that earth pit resistance shall be less than 1 Ohm at panel.

SPD s associated with the control and instrumentation system shall be earthed to the instrument earth in accordance with the SPD manufacturer's recommendations.

6.16.8 Galvanising

Wherever galvanising has been specified, the hot dip process shall be used. The galvanised coating shall be of uniform thickness. Weight of Zinc coatings for various applications shall not be less than those indicated below:

a) Fabricated Steel

Thickness less than 2 mm, But not less than 12 mm	340 gms / sqm
Thickness less than 5 mm, but not less than 2 mm	460 gms / sqm
Thickness 5 mm and over	610 gms / sqm

b) Fasteners

Up to nominal size M10	270 gms / sqm
Over M10	300 gms / sqm

Burrs shall be removed before galvanising. Any site modification of galvanised parts should be covered well by zinc rich primer and aluminium paint.

6.17 Insulating Mat

Insulating mats shall conform to IS 15652. The Supplier shall be made from the material Elastomer and free from any insertions leading to deterioration of insulating properties for floor covering in front or the MV and LV switchgear along its length.

Mats shall be free from fabric insertions and fibrous material and resistant to acid, oil & low temperature. Mats shall be solid and no perforated. The upper surface shall have small aberration (rough surface without edge) to avoid slipper effects while the lower surface shall be plane or could be finished slip resistant without affecting adversely the dielectric property of the mat.

The mats shall have class-D with minimum thickness of 3.5 mm without negative tolerance.

Mats of both types shall have a minimum width of 900 mm. Mats shall be satisfactorily vulcanized, free from blisters, pinholes, cracks, embedded foreign matter and other physical defects.

Minimum insulation resistance for the mats with tap water (i.e., wet condition) will be of 1,00,000 MΩ, when measured with 5000 V Megger or 10,00,000 MΩ, when measured with 500V Megger.

Insulating mats shall be marked with standard marks and Bureau of Indian Standards number.

6.18 Solar PV Panel Equipment Specification

6.18.1 Solar PV Module

Reference Standard	**Title**
IEC 61215	Silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval
IEC 61730-1	Photovoltaic (PV) module safety qualification – Part 1: Requirements for construction
IEC 61730-2	Photovoltaic (PV) module safety qualification – Part 2: Requirements for testing
IEC TS 62804 - 1	Photovoltaic (PV) modules – Test methods for the detection of potential – induced degradation- Part 1: Crystalline silicon
IEC 61829	Photovoltaic (PV) array – On-site measurement of current voltage characteristics
UL 1703	Standard for Flat-Plate photovoltaic modules and panels
IEC 61701	Salt mist corrosion testing of photovoltaic (PV) modules
IEC 61345	UV test for photovoltaic (PV) modules
IEC 62716	Photovoltaic (PV) modules – Ammonia corrosion testing
IEC 61853-1	Photovoltaic (PV) module performance testing and energy rating – Part 1: Irradiance and temperature performance measurements and power rating
EN 50548	Junction boxes for photovoltaic modules
IEC 60068 – 2 – 68	Environmental testing – Part 2 – 68: Tests – Test L: Dust and sand
IEC 60891	Photovoltaic devices – Procedures for temperature and irradiance corrections to measured I-V characteristics
IEC 62548	Photovoltaic PV arrays – Design Requirement
IEC 60904-1	Photovoltaic device (Part 1: Measurement of photovoltaic current – voltage characteristics)

a) PV modules shall be suitable for the site conditions, must have proven successful operation in utility-scale photovoltaic projects, and the PV module manufacturer shall have been on the list of TIER 1 for at least 3 years.

b) PV modules shall perform satisfactorily with operational temperatures between min + 5° C & max + 85°C and shall be available to work under 0~100% relative humidity.

c) Solar PV modules shall have positive power output tolerance between 0 to 5Wp. Negative power tolerance shall not be accepted.

d) Technical particulars of Solar PV modules are as per below

- Standard Test Conditions (STC) - 1000 W/m2 irradiance, Air Mass 1.5 and 25°C cell temperature.
- Nominal Operating Cell Temperature (NOCT) - 800 W/m2 irradiance, Air Mass 1.5, Ambient temperature 20°C and Wind speed 1 m/s.
- Average power reduction of 4.5% at 200 W/m2 shall be as per IEC 60904-1.
- Module Efficiency – minimum 20 %
- Power output (min) = 540Wp (@STC), 406.7Wp (@NOCT).

e) PV module junction box shall be in IP 68 protection class, and the PV manufacturer shall submit relevant certification accredited by third parties with:

- The junction box shall be proofed from dust, vermin, and water.
- The terminal shall be connected to a copper bus bar arrangement of proper sizes.
- Junction boxes shall have suitable cable entry points fitted with proper connectors of appropriate sizes for incoming and outgoing cables.

f) The module frame shall be made of corrosion-resistant materials, preferably an aluminium anodized finish.

g) The terms of the product guarantee for Solar PV modules shall include a minimum 25-year guarantee for physical conditions issued by the Solar PV module manufacturer.

h) Each module should have at least two 4 sq.mm stranded UV-resistant solar-grade cables that are at least 1000mm long.

i) The modules shall be protected by high-transmission, low-iron tempered glass covered with anodized aluminium alloy frames. Serially connected cells shall be terminated to IP 68 junction boxes at the bottom with 4 Sq.mm multi-strand copper cables.

j) Positive & Negative terminals shall be terminated with MC4 connectors, for making module interconnections.

k) Shade Effect:
The bidder shall consider the probable shading effects that may cause sunlight obstruction to the PV panels when designing the roof-top solar PV module. The following may be considered while designing the solar power generation, and a shadow analysis report shall be submitted.

- PV modules in proximity to the roof edges/parapet wall.
- PV modules near lift head room, staircase head room, building overhead water tanks, big trees (if any) etc.
- Mounting hardware height selection
- Module to module clearances.
- Performance Optimizers to maximise the energy output of PV system.

6.18.2 Module Mounting Structures (MMS)

a) Solar PV Module shall be suitably inclined to receive maximum insolation at the site. To accommodate more capacity and maximize generation output, the angle inclination may be optimized to achieve the best performance requirements. However, the overall layout of solar PV modules shall provide a minimum 1000 mm wide clear pathway all around to facilitate easy access and movement of maintenance personnel with equipment.

b) The Module Mounting Structure support and fixation arrangement shall be designed to not damage or deteriorate the strength, durability, and performance of the roof, including the water proofing carried out on the roof.

c) Roofs consisting of Metal Deck sheets with a concrete cover are unsuitable for fixing anchor bolts. The bidder, therefore, shall provide a module mounting arrangement with self-standing holding-down blocks/skids to be located on the purlins/ beams of the above-stated buildings. The type of mounting arrangement shall be selected depending on the roof's load-bearing capacity and applicable wind load at the roof level.

d) If the offered support structure is of the MS type, then the frames and complete leg assemblies of the array structures shall be Hot-Dip Galvanized. If the support structure is of Aluminium Alloy, anodization shall provide the necessary protection.

e) All fasteners, including Nuts and bolts, shall be Stainless steel—SS 304. Other hardware will have to be adequately protected against all climatic conditions.

f) The complete MMS, suitable supporting base/foundation, and connections shall be designed and submitted for approval before the start of manufacture/fabrication of MMS.

6.18.3 Solar String or DC cable

Reference Standard	Title
EN 50618	Electric cables for photovoltaic systems
CEI 20-91	Fire retardant and halogen free electric cable with Elastometric insulation and sheath for rated voltages not exceeding 1000V AC and 1500V DC for use in photovoltaic system (PV)
AK 411.2.3	Requirements for cables for PV systems
2 Pfg 1169/08.2007	Requirements for cables for use in photovoltaic systems
UL 854	Standard for service entrance cables
2 Pfg 1940/11.12	Requirements for cables for use on AC- applications in renewable energy systems
UL 4703	Outline of Investigation for Photovoltaic wire

Solar String Cables: String cables shall be of 1.5/ 1.8kV DC voltage grade, 1C x 4 Sq.mm, annealed tinned copper conductor, XLPO insulated unarmoured cables with operating temperature range from + 5^0 C° to +85°C from the PV module end to the String Inverter. The string cable shall be sized based on the acceptable/reasonable voltage drop/power loss.

Cables are essentially required to be Flame retardant, Have Low smoke emission, be halogen-free, and be resistant to UV, Ozone, and high temperatures.

The cable between PV Modules and String Inverters shall be laid in conduits/ cable trays.

6.18.4 PV Connector

Reference Standard	Title
UL 94V	Fire Resistant/ flammability
UL 486	Wire connectors
UL 746C	UV Resistant
UL 1977	Standard for safety component connectors for use in data, signal, control and power applications
EN 50521	Connectors for photovoltaic systems – Safety requirements and tests
UL 6703	Outline of Investigation for Connectors for Use in Photovoltaic Systems
UL 6703A	Outline of Investigation for Multi-Pole Connectors for Use in Photovoltaic Systems
IEC 60512-5-2	Connectors for electronic equipment – Tests and measurements – Part 5-2: Current – carrying capacity tests – Test 5b: Current-temperature de-rating
IEC 60664	Insulation coordination for equipment within low-voltage systems
IEC 61984	Connectors – Safety requirements and tests
IEC 62852	Connectors for DC application in photovoltaic systems. Safety requirements and tests

a) PV connectors are an integral part of the string connection of solar power. They are used to interconnect the solar modules/ harness to another solar cable, which is intended to further connect to the string inverter.

b) The connectors shall be MC4 (or MC4 compatible), UV-resistant, and ozone-protected. They should be rated for the same temperature range as the cables or better.

c) The PV module supplier shall provide all the PV connectors for use in the installation of solar fields. They must be solar grade, which can withstand harsh environmental conditions, including extreme temperatures from +5°C to +85°C, UV radiation according to HD 605/A1, ozone, rain, humidity, dirt, salt, burial and attack by rodents, moss, microbes, etc., and should

be made of double-insulated material of class II insulation rating having a minimal life span of 25 years.

d) They shall have an IP Class of at least 68. The used connectors must be equipped with a locking system to prevent the parts from being disconnected.

e) The MC4-type connectors should be TUV certified. The positive (+) terminal has a male connector, while the negative (-) terminal has a female connector.

f) The positive (+) wire must have a female MC4 connector, and the negative (-) wire must have a male MC4 connector that snaps together to form a connection suitable for outdoor environments.

g) The connectors must be push-in type and no need to crimp the connections

h) The MC4 connectors must be compatible with AWG 10, AWG 12 or AWG 14 wire/ cable with an outer insulation diameter between 2.5 and 6.0mm.

i) The cable connector to connect SPV modules and String inverters shall be per DIN EN 50521. The connectors shall be of a plug-and-socket design, to be plugged together by hand but can be separated again using a tool only.

j) The typical connector specification is as below:

Description	Nominal Values
Rated Voltage	1500V DC
Rated Current	25A
Connector type/ compatible	MC4
Locking System	Snap-in
Contact Material	Copper
Ambient temperature range	+5 °C to +85°C
Over voltage category/Pollution degree	CAT III/3
Max temperature	105°C
Contact Resistance	≤ 0.5mΩ
Type of termination	Crimping
Flame class	UL94-V0
Safety class	II
Approval	TUV

6.18.5 String Inverters

Reference Standard	Title
IEC 60068-2	Basic environmental testing procedures Part 2: Tests test Fd: Random vibration wide band – General requirements
IEC 61000-3-2	Electromagnetic compatibility (EMC) – Part 3-2: Limits for harmonic current emissions (equipment input current ≤16A per phase)
IEC 61000-3-12	Electromagnetic compatibility (EMC) – Part 3-12: Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current >16A and ≤75A per phase
IEC 61683	Photovoltaic systems – Power conditioners- Procedure for measuring efficiency
IEC 62109-1	Safety of Power converters for use in photovoltaic power systems – Part 1: General requirements
IEC 62109-2	Safety of Power converters for use in photovoltaic power systems – Part 2: Particular requirements for inverters

UL 1741	Standard for inverters, converters, controllers and interconnection system equipment for use with distributed energy resources
EN 50530	Overall efficiency of grid connected photovoltaic inverters
IEC 62116	Utility-interconnected photovoltaic inverters – Test procedure of islanding prevention measures

a) The inverter shall be suitable for outdoor applications and suitable for grid connectivity. Enclosure design must ensure adequate ventilation of the inverters in the enclosures, as per the manufacturer's indications, that the adequate ventilation system is to respect the inverters temperature range as defined in the technical specifications.

b) The operating temperature of inverters shall be between the range of +5°C and +85°C and higher range should be preferred.

c) The inverter's max efficiency and euro efficiency shall not be below 98%. Inverters with higher efficiency should be preferred. Also, the inverter's efficiency shall be equal to or more than 98% at 75% load as per IEC 61683.

d) Relevant regulations and grid code as amended and revised from time to time shall be complied. The power conditioning unit shall adjust the voltage & frequency levels to suit the Grid.

e) The inverters must have the feature to work in tandem with other similar inverter's and be able to be successively switched "ON" and "OFF" automatically based on solar radiation variations during the day.

f) A maximum power point tracker (MPPT) shall be integrated in the power conditioner unit to maximize energy drawn from the Solar PV array. The MPPT should be microprocessor-based to minimize power losses.

g) The inverter shall be capable of controlling power factor dynamically.

h) Sleep Mode: An automatic sleep mode shall be provided so that unnecessary losses are minimized at night. The power conditioner must also automatically re-enter standby mode when the threshold of standby mode is reached.

i) Stand – By Mode: The control system shall continuously monitor the output of the solar power plant until pre-set value is exceeded & that value to be indicated.

j) Inverter shall have provisions/features to allow interfacing with monitoring software and hardware devices.

k) Inverter shall have arrangement for adjusting DC input current and should trip against sustainable fault downstream and shall not start till the fault is rectified.

l) Terms of Product Guarantee of Inverters shall include minimum 10 years guarantee for physical conditions which is issued by the Inverter Manufacturer.

m) The String Inverters shall have provision of RS485 communication interface.

n) There will be multiple string inverters of various ratings and sizes used in this project based on PV Array capacity on roof of each building.

o) A typical string inverter specification is as below:

Description	**Nominal Values**
Input (DC)	
MPP voltage range	520 - 800V
Max. DC voltage	1000V

Max. DC current	22A/MPPT, 44A
Number of DC inputs	4
Start-up Voltage	>250V
Rated Voltage	635V
Output (AC)	
Nominal AC Voltage	3 Ph, 415V
AC Voltage Range	415V ± 10%
Max. AC current	32A
Output Frequency	50Hz ± 5 Hz
Max. THD	< 3%
Power factor	0.8 lag – 0.8 lead
Efficiency	98 % (min)

6.18.6 AC Cables

Reference Standard	**Title**
IEC 60189-1	Low-frequency cables and wires with PVC insulation and PVC sheath – Part 1: General test and measuring methods
IEC 60227-1	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V
IEC 60227-2	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 2: Test methods
IEC 60228	Conductors of Insulated Cables
IEC 60287-1-1	Electric cables – Calculation of the current rating – Part 1-1: Current rating equations (100 % load factor) and calculation of losses – General
IEC 60364-1	Electrical installations of buildings – Part 1: Fundamental principles, assessment of general characteristics, definitions
IEC 60364 – 7 - 712	Low-voltage electrical installations - Part7- 712: Requirements for special installations or locations – Photovoltaic (PV) systems
IEC 60754-1	Test on gases evolved during combustion of materials from cables – Part 1: Determination of the halogen acid gas content
IEC 60754-2	Test on gases evolved during combustion of materials from cables – Part 2: Determination of acidity (by pH measurement) and conductivity
CEI 20-67	Guide to use of 0.6/1 kV cables

a) Cabling for AC systems will be designed to provide a safe, economic means of transmitting power from the inverters to the injection/ evacuation point. Cables will be rated for the operating voltage and have conductors and screens sized for operating currents and short circuit currents.

b) It is important that the cable chosen is specified correctly. The following will be considered when designing the cabling:

- The cable must be rated for the maximum expected voltage.
- The conductor should be able to pass the operating and short circuit currents safely.
- The conductor should be sized appropriately to ensure that losses produced by the cable are within acceptable limits, and that the most economic balance is maintained between capital cost and operational cost (losses).
- The conductors should be sized to avoid voltage drop outside statutory limits and equipment performance.
- Insulation should be adequate for the environment of installation.

- Special heat resistant cable shall be used where cables are likely to be exposed to hot metal. Heat shield shall be provided for protection of cables
- All cables covered shall be flame retardant (FR) unless specified otherwise. The outer sheath of PVC cables shall possess flame propagation properties
- Armouring shall be by single round galvanised steel wires where the calculated diameter below armouring does not exceed 13 mm and by galvanised steel strips where this dimension is greater than 13 mm.

6.18.7 LV Switchboards/ACDB

Reference Standard	Title
IEC 60947-1	Low-voltage switchgear and control gear, Part 1: General rules
IEC 60947-2	Low-voltage switchgear and control gear, Part 2: Circuit-breakers
IEC 61439	Low-voltage switchgear and control gear assemblies
IEC 61439-1	Low-voltage switchgear and control gear assemblies, Part 1: General rules
IEC 61439-2	Low-voltage switchgear and control gear assemblies-Part 2: Power switchgear and control gear assemblies
IEC 60364-1	Electrical installations of buildings – Part 1: Fundamental principles, assessment of general characteristics, definitions
IEC 60364 – 7 - 712	Low-voltage electrical installations - Part7- 712: Requirements for special installations or locations – Photovoltaic (PV) systems

a) The LV Switchboard/ AC distribution board shall be metal enclosed, cabinet type, wall mounted, single front, dust and vermin proof construction. It shall be suitable for indoor/outdoor installation.

b) The switchgear used inside the ACDB shall be of appropriate current rating as per Inverter maximum output current and it shall be suitable for 415V, 3ph, 4 wire connection.

c) ACDB shall be suitable for termination XLPE/PVC, armoured power cables of 0.65/1.1 kV grade. All cable entry shall be from top.

d) All provisions and accessories shall be furnished for termination and connection of cables, including removable gland plates, cable supports, crimp type tinned Copper/ Aluminium lugs, brass compression glands with tapered washer (Power Cables only) and Terminal blocks.

e) Terminal blocks shall be box-clamp type. 20% spare terminals shall be provided.

f) The outgoing from the LV Switchboard shall be terminated at the LT panel of the nearest Switchgear room/ control room. This LT panel shall have provision for a Solar feeder, where connections of Solar power output from one/ multiple building roofs shall be interconnected.

6.18.8 Earthing & Lightning Protection

A. Earthing

Reference Standard	Title
IEC 60050-195	International Electrotechnical Vocabulary (IEV) - Part 195: Earthing and protection against electric shock
IEC 60364-1	Low-voltage electrical installations – Part 1: Fundamental principles, assessment of general characteristics, definitions
IEC 60364(4-41)	Low-Voltage Electrical Installations Part 4-41: Protection for safety Protection against electric shock

IEC 60364-5-54	Low-voltage Electrical installations – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements and protective conductors
IEC 61140	Protection against electric shock – Common aspects for installation and equipment
IEC 60479-1	Effects of current on human beings and livestock
EN 50522	Earthing Calculations for Safe system design
NFC 15 712-1	Low-Voltage Electrical installations - Practical Guide - Non-storage Photovoltaic installations and connected to the public Distribution network

a) The earthing system includes an earth electrode, installation of an earth electrode in a suitable pit size, construction of an earth pit with a cover, connection of the earth electrode with an equipotential earth bus, and connection of equipment to the equipotential earth bus. Earth pit construction shall be as per IS 3043-2018.

b) A dedicated earthing arrangement shall be provided for the lightning protection system.

c) Earthing system shall be designed with the following considerations:
   - Life Expectancy 25 Years
   - System fault level as per system requirement

d) Each PV Module frame shall be earthed per module manufacturer guidelines.

e) Each Module mounting structure (MMS) and PV module frame of the solar array shall be effectively earthed by two separate and distinct connections to the earthing system.

f) The body earthing of the Inverter, LV Switchgear panel, and AC distribution board shall be done with single-core flexible copper cable at two separate and distinct connections, and the same shall be connected to the earth pit through a riser.

g) All the earth pits shall be appropriately connected to maintained overall resistance of plant below acceptable limits.

h) On completion of installation, continuity of earth conductors and efficiency of all bonds and joints shall be checked.

i) Copper bonded steel rod shall be used for earth pit.

B. Lightning Protection

Reference Standard	**Title**
IEC 62305-1	Protection against Lightning – General Principles
IEC 62305-2	Protection against Lightning – Risk Management
IEC 62305-3	Protection against Lightning – Physical damage to structures & life hazard
IEC 62305-4	Protection against Lightning – Electrical & Electronic systems within structures
IEC 62561-1	Lightning protection system components (LPSC) - Part 1: Requirements for connection components
IEC 62561-2	Lightning protection system components (LPSC) - Part 2: Requirements for conductors and earth electrodes
IEC 62561-5	Lightning protection system components (LPSC) - Part 5: Requirements for earth electrode inspection housings and earth electrode seals
IEC 62561-6	Lightning protection system components (LPSC) - Part 6: Requirements for lightning strike counters (LSC).
NFC 17 102	Protection against Lightning - Early Streamer Emission Lightning protection systems

a) Lightning protection requirements shall be decided upon based on lightning protection calculations.

b) The lightning system shall comprise air terminations, down conductors, test links, earth electrodes, etc. Complete solar plant with associated structures, inverter, LV Switchgears/ AC distribution boards etc. shall be protected from direct lightning stroke as per calculation requirement.

c) The lightning protection system requirement for the PV plant shall be assessed according to IS/IEC 62305.

6.18.9 Transformer

a) Step up Transformer shall be converter duty, dry type of suitable voltage rating, 50 Hz shall be provided along with all protections, switchgears, circuit breakers, cables etc. and required civil work. The rating and vector group shall be as per manufacturer recommendation.

b) Dry-type transformer shall be constructed in accordance with IS / international standard. Transformer rating and all related technical parameters, including tap changer (if applicable), shall be as per system requirements and relevant standards. Transformer shall be suitable for continuous indoor duty application. Transformer shall be complete and functional in all respects. The other important construction particulars shall be as below.

- The transformers shall be housed in a metal protective housing, having a degree of protection of IP-44. The enclosure shall be provided with suitable hardware (as required).
- The conductors shall be of electrolytic grade copper free from scales & burrs.
- Dry Type Transformer windings shall be of class F insulation or better.
- The core shall be constructed from non-ageing, cold rolled, grain-oriented silicon steel laminations.
- The maximum losses for dry type transformer shall not be more than the values specified.
- The fittings/accessories including protection/monitoring device generally required for satisfactory operation of the transformer, are to be provided.

6.18.10 Tests

a) Type test certificate for the module shall be furnished. Tests shall be as per relevant codes and standards.

b) Routine tests on the modules shall be carried out as per the latest versions of the relevant codes and standards including flash test with sun simulator, visual inspection and identification of micro cracks with Electro Luminescence (EL) test etc.

6.19 Preferred Makes / Manufacturers

List of preferred makes for Electrical Equipment / Items

SL. NO.	DESCRIPTION	VENDOR / MANUFACTURER / MAKE
1	Distribution Transformers	M/s Crompton Greaves Limited M/s Volt Amp M/s Kirloskar Electric Co. Ltd. M/s. Kotsons

SL. NO.	DESCRIPTION	VENDOR / MANUFACTURER / MAKE
2	11 kV Metal enclosed switchboards	M/s Siemens M/s ABB M/s BHEL M/s Schneider Electric
3	Digital Protective Relays / meters	M/s ABB M/s Schneider Electric M/s Lauritz Knudsen M/s GE M/s Siemens M/s Mitsubishi Electric
4	Current Transformers - LT	M/s AE M/s ECS M/s Pragati M/s Kappa
5	Voltage Transformers - LT	M/s AE M/s ECS M/s Pragati M/s Kappa
6	LV Switchgears & Control gears (PCC's / MCC's / PDB's)	M/s Schneider Electric M/s ABB M/s Siemens M/s GE M/s L&T M/s Mitsubishi Electric Note: Authorized license partners / System Integrators of above manufacturer's shall be TTP certified for IEC 61439
7	LT Power Capacitors / Panel	M/s ABB M/s CG Power Systems M/s Universal M/s Madhav M/s BHEL M/s Lauritz Knudsen M/s Mitsubishi Electric Note: Authorized license partners / System Integrators of above manufacturer's shall be TTP certified for IEC 61439
8	Diesel Engines	M/s Cummins M/s Caterpillar M/s Kirloskar Oil Engines M/s Perkins M/s Greaves Cotton
9	Alternators for DG Sets	M/s Kirloskar Electric M/s CGL M/s BHEL M/s Stamford M/s Leroy-Somer

SL. NO.	DESCRIPTION	VENDOR / MANUFACTURER / MAKE
10	Variable Frequency Drives / Soft Starters	M/s Siemens M/s ABB M/s Schneider Electric M/s Mitsubishi Electric M/s Yaskawa M/s Danfoss M/s. Lauritz Knudsen Note: Authorized license partners / System Integrators of above manufacturer's shall be TTP certified for IEC 61439
11	Batteries	M/s Exide Industries M/s AMCO M/s HBL-NIFE M/s Amara raja
12	Battery Chargers	M/s Universal Instruments M/s Amara raja M/s Chabbi Electricals M/s HBL-NIFE
13	Lighting Fixtures and Accessories	M/s Philips M/s ABB M/s Crompton Greaves Limited M/s Wipro M/s Bajaj Electricals M/s Legrand
14	LT Bus Ducts	M/s Power Gear M/s C & S Electric Limited
15	Power Cables and Wires	M/s Universal Cables M/s Polycab M/s Havells M/s Finolex M/s NICCO M/s Delton M/s C & S Electric Limited
16	MLDB's, LDB's, SDB's, MCB's, RCCB's	M/s Havells M/s Standard M/s Legrand M/s Lauritz Knudsen M/s Siemens M/s Schneider Electric
17	Switches, Plugs, Sockets, Pushbuttons	M/s Legrand M/s Havells M/s Anchor M/s Cona M/s C & S Electric Limited
18	Ceiling Fans	M/s Havells M/s Crompton M/s Orient M/s Bajaj

SL. NO.	DESCRIPTION	VENDOR / MANUFACTURER / MAKE
		M/s Usha
19	Cable termination Kits	M/s Raychem M/s REPL M/s 3M

Note:

All products shall be completely manufactured in the country of Origin as indicated. Assembled products shall not be accepted.

Note-1: In order to achieve standardization for appearance, operation, maintenance, spare parts and manufacturer's service, like items of equipment provided hereunder shall be the end products of one (1) manufacturer.

Note-2: In the event that the contractor wishes to propose alternate makes for the equipment mentioned above, he shall submit the following during detailed engineering:

(i) Copies of Type Test Certificate (testing done as per latest standards) not older than 5 years for the items offered.
(ii) Demonstrate that the proposed makes are "equivalent" to the approved makes. The contractor shall ensure that alternate makes proposed, shall comply completely to the tender specifications, before the same is submitted for approval.
(iii) Submit ISO certificates for the OEM.
(iv) Submit quality certificates that the equipment adheres to, as required under this contract.
(v) Submit product brochures for the proposed equipment, testing facilities, with information on spares availability and service setup in employer's country.
(vi) Manufacturer involved in manufacture of specified proposed equipment for at least 10 years before bid date.
(vii) End user performance certificates for minimum 10 successful individual installations of similar size as per this contract with the proposed equipment and model no, commissioned & satisfactorily operating for at least 5 years before bid date.
(viii) Manufacturer to provide full contact information for each reference as part of submission.

End of Part-6

PART 7

STANDARD BASIC SPECIFICATION INSTRUMENTATION AND CONTROL WORKS

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PART 7

General Instrumentation Control & Automation Requirements

7.1 Introduction

This part covers the general requirements for the design, supply, installation, inspection, and testing of the instrumentation, control, and automation and associated plant and materials for WwTP and ISPS. At a minimum, WwTP and ISPS under this contract shall be provided with the individual instrumentation, control, and automation equipment as detailed under the general and particular requirements.

7.2 Reference Standards

Unless otherwise approved, all equipment shall comply with relevant quality standards, test procedures, and codes of practice collectively referred to as Reference Standards, including those listed below, following the requirements detailed elsewhere in this specification.

Generally, the latest edition of codes and standards prevailing at the time of award of contract shall be applicable.

7.2.1 Temperature Measurement

a) Instrument and apparatus for temperature measurement - ASME PTC 19.3 (1974).
b) Temperature measurement - Thermocouples - ANSI - MC 96.1 - 1982.
c) Temperature measurement by electrical resistance thermometers – IS : 2806
d) Thermometer-element-platinum resistance - IS: 2848 / DIN 43760

7.2.2 Pressure Measurement

a) Instrument and apparatus for pressure measurement - ASME PTC 19.2 (1964).
b) Bourdon tube pressure and vacuum gauges - IS: 3624/1996.

7.2.3 Flow Measurement

a) Instruments and apparatus for flow measurement - ASME PTC 19.5 (1972) Interim supplement, Part-II
b) Measurements of fluid flow in closed conduit - BS 1042.

7.2.4 Electronic Measuring Instruments and Control Hardware

a) Automatic null balancing electrical measuring instruments -ANSI C 39.4 (Rev. 1973), IS 9319
b) Safety requirements for electrical and electronic measuring and controlling instrumentation - ANSI C 39.5 / 1974.
c) Compatibility of analog signals for electronic industrial process instruments - ISA-S 50.1: ANSI MC 12.1 / 1975.
d) Dynamic response testing of process control instrumentation - ANSI MC 4.1 (1975) - ISA -S26 (1968).
e) Surge withstand capability (SWC) tests - ANSI C 37.90A (1989), IEC-255.4.

7.2.5 Instrument Switches and Contacts

a) Contact Rating - AC services NEMA ICS Part-2 125, A-600
b) Contact Rating - DC services NEMA ICS Part-2 125, N-600

7.2.6 Enclosures

a) Enclosures for Industrial Controls and Systems–NEMA ICS-6-110.15 through 110.22
b) Racks, panels and associated equipment -EIA: RS-310-B-1983 (ANSI C83.9 - 1972).

7.2.7 Apparatus, Enclosures and Installation Practices in Hazardous Area

a) Classification of hazardous area - NEMA Article 500, Volume-6, 1978.
b) Electrical Instruments in hazardous dust locations - ISA-RP 12.11.
c) Intrinsically safe apparatus - NFPA Article 493 Volume-4 1978.
d) Purged and pressurized enclosure for electrical equipment in a hazardous location
e) - NF Article 496 Volume-4, 1978.

7.2.8 Sampling System

a) Stainless Steel material for tubing and valves in the sampling system - ASTM A269-79 GRTO-316.
b) Submerged helical coil heat exchangers for sample coolers -- ASTM D11-98.

7.2.9 Annunciators

a) Specifications and guides for the use of general-purpose annunciators - ISA RP 18.1.
b) Surge withstand capability tests -ANSI C37.90 a -1971 and IEEE Standard 472- 1974

7.2.10 Interlocks, Protections

a) Relays and relay systems associated with electric power apparatus - IEEE Standards 3.13.
b) Surge withstand capability tests - ANSI C37.90 a - 1971 and IEEE Standard 472-1974.
c) General requirements and tests for switching devices for control and auxiliary circuits, including contactor relays - IS-6875 (Part I)/1973.

7.2.11 UPS System

a) Practice and requirements for semiconductor power rectifiers - ANSI C34.2.
b) Relays and relay systems associated with electrical power apparatus IEEE Standard - 3.13.
c) Surge withstand capability tests - ANSI C 70.90 A/1971, IEC-255.4.
d) Recommended practice for sizing large lead storage batteries for generating stations and sub-stations - IEEE-485.
e) Ni-Cd Battery - IEEE Std. 1106 /IS 10918

7.2.12 Instrument Tubing

a) Seamless Carbon Steel Pipe - ASTM-A-106.
b) Forged carbon steel fittings - ASTM-A-105.
c) Dimensions of fittings - ANSI-B16.11.
d) Code for pressure piping, welding, hydrostatic testing - ANSI-B 31.1.
e) Nomenclature for instrument tube fittings - ISA-RP 42.1 / 1982.
f) Seamless Stainless Steel Tube ASTM A-213 TP 316 / ASTM A-269 TP 316
g) Seamless Alloy Steel Pipe ASTM A 335 P22
h) Seamless Stainless Steel Pipe ASTM A-312 TP 316

7.2.13 Cables

a) Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy-IPCEA S-61-402

b) Guide for design and installation of cable system in power generating station (insulation, jacket materials) - IEEE Standard 422.
c) Requirements of vertical tray flame test - IEEE 383
d) Standard specification for tinned soft or annealed copper wire for electrical purpose - ASTM B33.

7.2.14 Electronic Cards, Subassemblies and Components

a) Unpackaged

i. Vibration	:	IEC-68.2.6
ii. Shock	:	IEC-68.2.27
iii. Drop & Topple	:	IEC-68.2.31

b) Packaged

Vibration, Drop & Static Compression - NSTA.

c) Electromagnetic Compatibility

i. Electrical Fast Transient	:	IEC-801.4
ii. Surge Withstand	:	IEC-255.4
iii. Radiated Electromagnetic Field	:	IEC-801.3
iv. Electrostatic Discharge	:	IEC-801.2
v. Electromagnetic Emissions	:	VDE 0871, Class-B

7.2.15 Cable Trays, Conduits

a) Guide for the design and installation of cable system in power generating station (cable trays, support systems, conduits) - IEEE Standard 422, NEMA VE-1, NEC-1981. Test Standards NEMA VE-1-1979.
b) Galvanizing of carbon steel cable trays - ASTM A-386.

7.2.16 Characteristics

1) ISO 9000 and 09004	-	Quality Systems
2) IEEE 587	-	Power Supply Surge Protection\
3) IEC 61158-2	-	Communication Protocols
4) ISO 9075 (BS 6964)	-	Structured Query Language (SQL)
5) BS 5515	-	Documentation of Computer Based Systems
6) BS 7165	-	Recommendation for Achievement of Quality in Software
7) BS EN 50081	-	Electromagnetic Compatibility
8) ISO 3511	-	Process measurement control functions – Instrumentation symbolic representation
9) ISO-OSI	-	7 Layer Communication Model
10) IEEE 472-1974	-	Surge protection.

All standards which the Contractor intends to use but which are not part of the above Standards or other listed Reference Standards, shall be submitted to the Employer Representative for consent before any design against that standard proceeds.

7.3 Documents to be submitted by the Bidder during Bid Submission for technical bid qualification for Instrumentation Control & Automation

Note: In addition to the below information to be submitted, the technical schedule shall be completed in full for technical bid qualification. Bidder to note the importance of this requirement.

1. Provide a block diagram of the proposed system showing all major components and their interconnections and interrelationships. Label each diagram and indicate all external power and communications interfaces.

2. Provide a written overview of the proposed control & instrumentation system describing the principal functions and capabilities of the entire system (PLC-based SCADA), system communications, software & hardware, integration, and general system capabilities as required under the general & particular requirements of ICA (Parts 7 & 13).

3. Provide a written description of the fire alarm, detection, and suppression system and its integration with the plant PLC-based SCADA system.

4. Provide an equipment list with descriptive literature for the proposed system. Included on the list shall be all hardware & software items. List shall include at a minimum, the manufacturer, the quantity provided, and model numbers for each. Technical schedules for instruments, PLC & SCADA, and all other equipment shall be duly filled with all relevant details without any deviations with the bid requirements. The technical schedule shall be completed in full for technical bid qualification. Bidder to note the importance of this requirement.

5. Provide an operating system and software applications list with descriptive literature for the proposed system. Include all major software items, supplier name, quantity, and model numbers. Indicate whether any proposed software is proprietary and would not be turned over to the owner.
   Note: Proprietary software will not be accepted.

6. Technical details are required for the following without any deviation as per bid requirements:
   - Name and version of the proposed SCADA software Package.
   - Name and version of the PLC online/off-line programming software for all controllers, inclusive of vendor-supplied systems (if any).
   - Name and version of the PLC,
   - Name and version of the PLC I/O Modules,
   - Name and version of Historian software
   - Name and version of any required communications software, firmware, etc.
   - Name and version of the specified report application software,
   - Name and version of the specified LIMS software & agency as per bid requirements
   - Provide a description of any non-resident software required to program, troubleshoot or diagnose any devices in the system.
   - Submit resumes of ICA engineers who will be in charge of the design of works as required under this contract. The ICA engineer who shall be in charge of the design of works from the Contractor, shall have a minimum of 10 years' experience of having designed, executed & completed PLC-based SCADA systems for WwTPs as required under this contract.
   - The above documents shall be submitted in proper bound form and indexed with page numbering for easy referencing. All catalogs and literature (including sub-suppliers' catalogs), datasheets, instrument lists, etc. shall be bound, bound together in indexed volumes. The Contractor shall submit all the documents with indexing with page numbering for easy reference
     Note: The Contractor shall provide all the above required details/documents as qualification criteria during bid submission. Failure to do so will be treated as a non-responsive bid *and lead to technical disqualification***.** The Contractor should note the importance of the obligation.

7.4 Project Requirements

1) Contractor shall provide material, equipment and services specified or otherwise required to fulfill the intent of the specification and to integrate into a fully functional Instrumentation and Control system, ensuring operability, maintainability, reliability, and durability for a comprehensive operation & maintenance period of seven (7) years described in this specification.

2) Contractor shall furnish their offer based on the requirements as described in the specification.

3) The scope of supply shall include but shall not be limited to the following:

a) Field instruments and sensors for remote measurement, Primary flow elements along with branch pipes, root valves, nipples, flanges, nuts, bolts, gaskets, and accessories.
b) Instrumentation pair, triad & core cable, instrumentation power cable, optical fiber cable, special cable, etc, cable trays, as required.
c) Control panel, panel instruments, field junction boxes, instrument enclosures, accessories, and furniture (system consoles), as required.
d) Required power supply
e) Supply of all start-up, commissioning and recommended spares in addition to the mandatory spares.

4) Contractor shall provide local panels for local start/stop/E-Stop monitoring of auxiliaries and equipment as per the requirements to be decided during the detailed engineering stage. Ingress protection of panels shall be as per the requirements mentioned in this document.

5) Local Panels, Gauge Boards and Transmitter Racks, stanchions, brackets etc. as required.

6) Process connection and piping materials including impulse pipes of different grades & stainless steel tubes, stubs, bosses, root valves, isolation & drain valves, valve manifolds, gauge valves, condensate pot, fittings, stands, brackets, etc., as applicable, for satisfactory installation of all field instruments and analysers.

7) Pneumatic tubing along with fittings and isolating cocks for air consumers.

8) Erection hardware, including junction boxes, canopies, field enclosures for all instrumentation, structural steel items, viz, steel angles, channels, flats.

9) Complete cable accessories viz flexible conduits, sub-trays/perforated trays, pull boxes, inspection covers, bends, elbows, mounting brackets, clamps, nuts and bolts, glands, lugs, ferrules, connectors, markers, tray supports, rigid conduits, tie wraps etc.

10) Complete optical fiber cable and special cables with accessories, including optical fiber distribution boxes, patch cords, terminators, taps, and heavy-duty conduits, to make the system complete in all respects.

11) Rating plates, Nameplates and Labels.

12) Maintenance, calibration, commissioning, site testing and troubleshooting equipment.

13) Fiber optic cable and accessories, including tray /conduit for system data network and for data collection through Modbus, Ethernet, or OPC connectivity, wherever required.

14) Arranging all performance test instruments and equipment.

15) Instrument control panels.

16) Performing tests on all equipment as per the Quality Plan prior to shipment.

17) Contractor shall be responsible for software licensing, design, development, debugging, system engineering, customizing, installation, site modification, tuning, adjustments, commissioning and furnishing manuals, documentation etc.

18) Drawings and Documents: Contractor shall furnish system description, operational write-up, bill of materials, drawings, data, information, technical catalogues, test certificates, and other details to establish the provenness, capability, and performance of the equipment and systems offered.

19) Final Drawings

a) The Contractor shall obtain written approval from the Employer for the design drawings identified as "Approved". Any manufacture done prior to approval of the drawings shall be rectified in accordance with the approved drawings by the Contractor at his own cost and time, and the equipment shall be supplied within the stipulated period.
b) Contractor shall furnish final drawings and documents in multiple (3 sets) hard and soft copies. Contractor shall furnish instruction manuals containing various components, sub-assemblies, method of installation, check-ups, and tests to be carried out during erection and commissioning of the equipment. The manual shall also include instructions for step checking, troubleshooting, and fault rectification for different components and sub-assemblies.
c) Contractor shall incorporate all modifications in the drawings carried out at the site during the trial run, start-up performance, and guarantee tests till hand over of the units to the Employer and submit these final as-built drawings both in hard and soft copy.
d) Final documents shall be submitted in proper bound form. All catalogues and literature (including sub-suppliers' catalogues), datasheets, Instrument list, input output list, function control diagram, loop diagrams, configuration diagram, etc., shall be bound together in indexed volumes. All O&M manuals shall be in handy size and neatly bound for carrying to the workplace.
e) Contractor shall convert all drawings and documents, manuals under this contract into PDF format and store them in the operator workstation at the SCADA control room.
f) Operation and maintenance instructions
1) Composite manual describing the functional and operation of each piece of equipment.
2) Composite manual for testing and servicing every system and individual item.
g) Original manuals and CDs from OEMs.
h) Training material shall be provided, which shall include the presentations used for training and also the required relevant documents for the topics.

The selected Contractor shall submit a complete set of:

1) Floor Layout Drawings,
2) Single Line diagram.
3) Complete cabling system layout (as installed), including cable routing.
4) The layout shall detail locations of all components and indicate all wiring pathways.
i) The Contractor shall be responsible for preparing process documentation related to the operation and maintenance of each component of the Instrumentation, Control, and Automation system.
j) The prepared process document shall be formally signed off by the end user before completion of the final acceptance test.
k) The Contractor shall document all the installation and commissioning procedures and provide the same to the end user, within one week of the commissioning of the project, along with final configuration dumps and implemented solution details.

l) The Contractor shall be responsible for documenting the configuration of all devices and keeping a backup of all configuration files, so as to enable quick recovery in case of failure of devices.

7.5 Qualification Criteria for Instrumentation agency, Control & Automation agency, Lab equipment agency for design, supply, program, execution, and commissioning of works

The Contractor shall submit the following documentation for review and approval, as part of credentials submissions of the agency, for design, supply, program, execute, and commission the works to the Employer Representative, before commencing any design ,supply, or associated works. Only upon approval, the Contractor shall commence the design and other associated works. Contractor shall note the importance of this clause.

Note-1: The Contractor shall note that the approved vendor list indicated in particular requirements (Part-13) for Instrumentation, control, and automation, is only for the product make indicated.The Contractor shall submit the credentials of the agency that shall be supplying & executing (design, supply, program ,execute, and commission) the work for review and approval as per the qualification criteria indicated below. The agency/OEM for design, supply, program, execution, and commissioning the works shall comply with the qualification criteria as indicated below, at a minimum.

Note-2: There shall be a single agency which shall design, supply, program, execute, and commission the works to ensure uniformity among equipment and spare holding.

Instrumentation:

The agency shall be operating under an accredited ISO 9001:2015 system.

The agency should have minimum 10 years of experience in India in the field of instruments supply, installation, commissioning and operation and maintenance of instruments in plants as required under this contract, within India and shall demonstrate capability and resources for integrating/interfacing control systems from different manufacturers as well as coordination with multiple agencies for contract execution. The agency shall be an authorized channel partner for the instrumentation equipment. Verification certificates signed by the country head of OEM shall be submitted.

The agency shall have executed & completed at least Five (5) WwTP projects within India during the last Five-year period, inclusive of supply, installation, commissioning, and operation and maintenance period of a minimum of 1 year within India.

Control & Automation:

The Contractor shall submit the following documentation as part of credentials submissions for the control & automation agency for design, supply, and program, execute and commission the works.

The agency which shall design, supply, program, execute and commission control and automation equipment, at a minimum**,** shall be operating under an accredited ISO 9001:2015 system, with a minimum of 10 years' experience of having designed, executed & completed PLC based SCADA systems for WwTP's, inclusive of supply, installation and commissioning; and operation and maintenance period of minimum 1 year on a single facility within India during the last five years and shall demonstrate capability and resources for integrating/ interfacing control systems from different manufacturers as well as coordination with multiple agencies for contract execution.

The agency shall be an authorized channel partner for the named PLC hardware & SCADA software for a minimum of 5 years on a continuous basis to date. Verification certificates signed by the country head of OEM or higher shall be submitted. The agency proposed personnel shall be trained on a yearly basis by the product OEM on the proposed control system. Agency shall submit documentation to validate the same as part of credentials submission. Verification certificates signed not less than the country head of OEM shall be submitted.

The agency shall demonstrate an in-house FAT facility with a FAT simulation panel and other required hardware and software to conduct FAT as required under this contract. The agency shall submit documentation to validate the same as part of the credentials submission.

The Agency at a minimum, shall have executed & completed at least Ten individual WwTP contracts of minimum 20 MLD capacity for control and automation each, out of which, at least one WwTP shall be with the WwTP process (extended aeration process) of minimum 20 MLD within India, during the last five years period. Verification of end-user performance certificates shall be submitted for the same.

Note: In the event that the OEM intends to execute (design, supply, program, execute, and commission) the works, the OEM shall comply in full with the qualification criteria as required in this clause & specification.

The agency shall have an automation manager with a minimum of fifteen years of relevant experience and at least two team leaders with a minimum of seven years of relevant experience. The agency shall have a minimum of five design engineers with at least three years of relevant experience in design, installation, and commissioning of works similar to this contract, and overall capacity and process. The engineers shall be on permanent employment. Proof of PF should be submitted to demonstrate permanent employment. (Associate Employer Representatives/ Advisers/ consultants shall not be considered).The agency shall submit documentation and signed resumes of the personnel as part of the credentials submission. The Contractor and agency shall depute only approved personnel, who's resume has been approved.

Lab Equipment

The agency shall be operating under an accredited ISO 9001-2008 or above Quality System at a minimum.

The agency shall be an authorized channel partner for the equipment.

The agency shall have executed & completed at least five projects for setting up of WwTP /drinking water lab & testing facility within India in Public sector units/Govt. agencies during the last three years period, inclusive of supply, installation, commissioning of the laboratory equipment. Verification end user performance certificates shall be submitted for the same.

7.6 Design Submissions to be submitted by the Contractor during the contract period:

1) The Contractor shall make submissions to the Employer Representative of all design drawings, schedules and complete documentation on spare parts relating to instrumentation and control equipment and systems provided under this Contract.
2) These submissions shall include, the following on a minimum :

A. P&ID

a) Process and instrumentation diagram shall be as per ISA 5.1 latest release. The P&ID shall contain the following and in sequence:

1) Legend sheet, inclusive of process line abbreviations, line designations, process designations, symbols for all equipment, etc.
2) Tag Identification system. (Note: The tagging philosophy shall be submitted before the submission of the P&ID for review and approval before the tag, i.e., is incorporated in the P&ID.)
3) Typical Signal interface sheet
4) Process and Instrumentation sheets, as per each process, which shall depict the interlock sequence for each piece of equipment and process operation. The interlock sequence shall be depicted by using interlock numbering next to the equipment/process.
5) Interlock sheet detailing every interlock for the system (Pumps, drives, blowers, valves, etc.). For e.g.: Start, Stop, Trip, sub-process sequence, etc.
6) Each P&ID shall be submitted along with the process control philosophy.
7) The above requirements are also applicable to vendor-supplied systems P&ID.

B. Instrumentation

a) Functional design specification (FDS) The Contractor shall submit a complete Functional Design Specification (FDS) for approval by the Employer Representative within five (5) months of the award of the Contract. The Contractor should take note of the importance of this clause.

The functional design specification shall be submitted for the following

b) The Contractor shall submit the instrumentation schedule based on code-B approved P&ID.
c) Instrument schedule shall be submitted and approved before the submission of Instrumentation FDS.
d) The FDS shall include Instrument datasheets, Instrument location layouts, OEM product brochure, Instrument hook up diagrams and quality assurance plan for functional testing & inspection at the factory where the equipment has been manufactured, spare part list, spare parts availability letter from the OEM and service support from authorized agencies, shall provide list of service agencies authorized for the same.
e) General arrangement drawings of field-mounted instruments showing installation details.
f) General arrangement drawings of instrument and control panels, fully dimensioned in plan and elevation views, showing foundation and fixing details, access doors, clearances, cable-entry positions, weight and lifting arrangement.
g) Layout drawings of panel fascias showing instruments, controls, and details of all labels.
h) Internal circuit and wiring diagrams for instrument and control panels.
i) Schematic control diagrams.
j) Instrument loop diagrams.
k) Instrument wiring and piping diagrams.
l) Interconnection wiring diagrams.
m) Cable block diagrams, drawings, and schedules.
n) Instrument system and panel power distribution diagrams.
o) The FDS shall describe control actions taken and monitoring functions which remain available during a power failure, and any automatic controls or sequencing which take place during system start-up and shut-down.
p) The FDS shall be presented in a clear and precise manner and shall include figures or drawings where appropriate.
q) Comprehensive testing schedules for all off-site, on-site, pre-commissioning and commissioning tests and take-over tests.

C. Control & Automation

1) Functional design specification (FDS) The Contractor shall submit a complete Functional Design specification (FDS) for approval by the Employer Representative within five (5) months of the award of the Contract. The Contractor should take note of the importance of this clause. The functional design specification shall be submitted for the following
2) This document shall serve as the primary mechanism by which the Employer Representative may confirm that the Contractor possesses an accurate understanding of the system and its control requirements.

a) At a minimum, FDS shall comprise an overall description of the plant, its functioning and control, a detailed description of each section of the control system covering modes of operation, manual overrides, set-point and parameter selection and adjustment. The detailed description shall include a step-by-step control description which defines the function of each piece of equipment and each control action and interlock, including details of the program in each programmable item. Flow charts shall be used to depict the control philosophy along with the write-up for the same.
b) Proposed SCADA screens shall be an integral part of the submissions.
c) The FDS shall describe the 'fail-safe' features incorporated into the design for the event of failure of a plant item or system, or loss of an input signal.
d) The FDS shall describe the control actions taken and monitoring functions that remain available during a power failure, as well as any automatic controls or sequencing that occur during system start-up and shut-down.
e) The FDS shall be presented in a clear and precise manner and shall include figures or drawings where appropriate.
f) Drawings and schedules as part of FDS (For both Instrumentation & Control & Automation):
r) General arrangement drawings of field-mounted instruments showing installation details.
s) General arrangement drawings of instrument and control panels, fully dimensioned in plan and elevation views, showing foundation and fixing details, access doors, clearances, cable-entry positions, weight and lifting arrangement.
t) Layout drawings of panel fascias showing instruments, controls, and details of all labels.
u) Layout drawings of panel interior showing equipment, terminal blocks, and cableways.
v) Annunciator arrangement and engraving details.
w) Internal circuit and wiring diagrams for instrument and control panels.
x) Schematic control diagrams.
y) Instrument loop diagrams.
z) Instrument wiring and piping diagrams.
aa) Interconnection wiring diagrams.
bb) Cable block diagrams, drawings, and schedules.
cc) Instrument system and panel power distribution diagrams.
dd) Programmable-device functional design specifications, which shall include hardware details, control philosophy, logic flowcharts, ladder diagrams, and program listings
ee) Schedules of inputs to and outputs from programmable controllers and telemetry outstations.
ff) Labelling & tag schedules.
gg) Comprehensive testing schedules for all off-site, on-site, pre-commissioning, and commissioning tests, as well as takeover tests.
hh) All other drawings necessary for the provision of ducts, openings, trenches, fixing holes for panels, and the like, and for the complete understanding of the operation, maintenance, and extension of the system, including any required for the Purchaser to dismantle, repair, maintain, modify, or extend the Plant.
ii) Control room, RIO Room interior design layouts, interior design diagrams, control room wiring layout, access control point diagrams, etc.
jj) Data and calculations
kk) Manufacturers' catalogues and data sheets.

ll) Calculations to support the design of the control system.
mm) Specification for Protective Coatings and Painting.
nn) Certificates
oo) Manufacturers' works tests.
pp) Pre-installation checks.
qq) Pressure-testing schedules.
rr) Instrument loop test check sheets.
ss) Installed instrument performance tests.
tt) System tests.
uu) Statutory certificates of compliance (such as hazardous area equipment).

Note: The Contractor shall submit and obtain approval of the FDS from the Employer Representative before beginning procurement. The Contractor should take note of the importance of this obligation.

7.7 Design Requirements for Instrumentation, Control & Automation System

Minimum Design Consideration

The instrumentation, control & automation system shall fully comply with design standards, regulations and the material and workmanship requirements of the Specification.

The electrical plant installations associated instrumentation control and automation systems shall also comply with and be tested as per the latest edition of BS 7671 or equivalent Indian standards.

All equipment and materials incorporated in the system shall be selected, designed, and rated to operate under the defined performance duties and specified site conditions and to maintain a high level of operational reliability.

The instrumentation control and monitoring system's equipment and materials shall have an operational life of at least ten (10) years.

Instrumentation, Control, and Automation system shall be designed, manufactured, and installed to achieve the following basic requirements:

- to maintain the highest standards of availability, reliability and accuracy and to give clear warnings of any deterioration in performance;
- to suit the abilities of the staff who will:
  - use the systems;
  - service the systems;
- to measure, indicate, process, store, and control the relevant parameters, as specified;
- to give clear warnings of dangerous and other abnormal conditions and to initiate plant safety procedures, shutdowns, and corrective measures as specified to assure the safety of 'operations and maintenance' personnel and plant and to store and collate the data, as required;
- to derive, present, and utilize, as required, such additional data as required to facilitate:
  - the most efficient operation of the plant;
  - the routine maintenance of the plant

Equipment and system shall be designed and constructed to perform accurately and safely under the environmental and operating conditions described or implied in this specification without undue heating, vibration, wear and corrosion.

Equipment and systems shall be supplied as per the vendor list indicated in the specification elsewhere.

The equipment, systems, and accessories furnished shall be designed and constructed to meet the performance specification during the continuous service life of the plant.

The Contractor shall indicate the year in which the offered models of the instruments and control system have been introduced and how long the commercial production of the same is expected to continue. In any case, Contractor shall ensure the supply of spare parts for a minimum period of ten years. In case it is felt by the Contractor that certain equipment/ component is likely to become obsolete, the Contractor shall clearly bring it to the notice of the Employer and indicate the steps proposed to deal with such obsolescence, such as maintaining "bonded spares" with the manufacturer/s.

Any part/ module of the C&I system which are not listed under recommended spares shall be deemed as having a life expectancy of not less than ten years.

The Contractor shall supply the proven latest version of hardware and software available at the time of system design. In case of future up-gradation of software, Contractor shall remain committed to upgrade the supplied system at per with the new version within the warranty period and O&M period and ensure successful integration of the system.

For the sake of completeness of the system and in order to ensure desired performance & safety measures, any hardware or software item felt required, shall be in the scope of the Contractor, irrespective of their explicit or implicit inclusion in the accompanying document.
The technical details furnished in the accompanying documents are subject to change in the future within reasonable limits, which the Contractor shall adhere.

7.8 General Technical Requirements

7.8.1 Local Instruments

Required local instruments including gauge boards, level indicators etc. shall be provided.

7.8.2 Cabling Concept

Instrumentation cables shall be copper, overall screened unless manufacturer's recommendation dictates use of pair or triad shields apart from overall shield. All cables shall generally be armoured, other than short run cables which may be unarmoured. Unarmoured cables shall run through conduits.

Binary and analog signals should not be transmitted over the same cable. Signals of different voltage levels shall not be routed through the same cable. The screen shall be grounded at the control room end only.

The conductor cross section for single-pair or triad signal cables shall not be less than 1.5 mm^2, and the conductor cross section for multi-pair or multi-triad cables shall not be less than 0.5 mm^2. For solenoid valves, depending on the pick-up VA, the individual conductor cross-section shall not be below 2.5 mm^2. For an interposing relay drive connection, the individual conductor cross-section shall not be below 1.5 mm^2.

7.8.3 Design Criteria

This section lays down the general design criteria to be adapted in designing the instrumentation and control system

7.8.4 General Requirements

Instrumentation and control devices and accessories shall be designed with the following considerations:
a) Stable despite temperature fluctuations.
b) Able to withstand high humidity.
c) Weatherproof.
d) Dust proof.
e) Corrosion resistant.
f) Erosion resistant.
g) Able to withstand high vibration.
h) The entire control System for the plant shall be designed for complete automatic operation with operational interlocks as required.
i) Easily accessible for operation & maintenance.

Parts subject to high pressure, temperature, or other severe duty shall be made of materials and constructed to suit the service conditions and ensure a long operating life.

7.8.5 Instrument Accuracy, Standard Scales and Ranges

7.8.5.1 Instrument Accuracy

Instruments shall meet the following general requirements.
a) Pressure measurement shall be linear with respect to the measured pressure.
b) The flow meter shall meet the specified accuracy criteria when operating between 25 and 100 % of full-scale flow. The accuracy shall include the effect of errors in the differential head measuring device, square root converter and signal generator.
c) Level measurement shall be linear with respect to the measured level, based on a medium with a specific gravity of 1.00.

7.8.5.2 Instrument Scale Displays

a) All displays shall be in engineering units. Instrument scales displayed on screen will have graduations with scale divisions based on multiples of 10. The smallest division shall preferably be a whole number, approximately 1% of the scale range, unless otherwise impracticable.
b) Pressure instrument shall have the unit suffixed with ‘a’ or ‘g’ to indicate absolute or gauge pressure, respectively.
c) Scales and charts of all instruments shall have linear graduations

7.8.5.3 Instrument Ranges

The instrument range shall be selected to have a normal reading, preferably between 50% and 70% of full scale for linear parameters and between 70% and 80% for flow measurements. Deviation indicators shall have their null position at the mid-scale. The normal operating parameter shall be identified with a clear green mark.

7.8.6 Established Reliability & Availability of individual instrument system

The target reliability of each component/module shall be established by considering its Mean Time Between Failure (MTBF) and Mean Time to Repair (MTTR), ensuring that the availability of each system is assured for 99.7% of the time.

To establish the target reliability, the Contractor shall conduct necessary availability tests. Surge protection for solid-state systems, the selection of proper materials, manufacturing processes, and quality-controlled components and parts, as well as adequate derating of electronic components and parts, shall be ensured to meet the reliability and life expectancy goals.

Continuous self-checking features shall be incorporated in system design with automatic transfer to healthy/redundant circuits to enhance the reliability of the complete system.

7.8.7 Measurement & Channel Redundancy

To meet the failure and self-checking criteria for the control system, measurement redundancy shall be provided for all the critical parameters. Throughout the control system, the security and validity of signals are to be ensured based on the following design principles.

a) Where a plant measurement is to be duplicated or triplicated, such signals shall be separately fed to the different input modules.
b) Signals, after due security and validity checking using voting, averaging, median, and difference monitoring or similar technique shall be used for control functions.
c) Where duplicated measurements are used, provision shall be made for selecting any one as the duty signal. Continuous monitoring of the difference between the signals shall be made.
d) Signals shall be verified against cable failure.

7.8.8 Design of Enclosures

Design of outdoor enclosures shall be weather-proof (IP-65), dust-tight, drip-proof, and shall take into account the environmental conditions.

Enclosures shall be adequately sized so that the maximum permissible temperature rise above ambient is 10 ^{O}C (maximum).

Enclosures design shall also take into account the greatest possible personnel safety.

All instrumentation, including analytical instrumentation, shall be mounted inside IP-65 rated enclosures, irrespective of the transmitter's IP rating.

7.8.9 Electrical Noise Control

Equipment furnished by the Contractor shall incorporate necessary techniques to eliminate problems caused by electrical noise interferences and power line-borne surges encountered in a power plant environment. Equipment, which is vulnerable to electrical noise interference or surge, shall be suitably insulated to eliminate possible problems.

7.8.10 Surge-Protection for Solid State Equipment

All solid-state equipment shall be able to withstand the surges inherent in a working environment. Equipment shall be designed to successfully withstand surges without damage to components and/or wiring on application of surge wave whose shape and characteristics are defined in ANSI publication C37.90-a (IEEE-472-1974) entitled "Guide for Surge Withstand Capability (SWC) Tests".

To immunize the system against surge, coupling free- wheeling diodes, surge suppressors, optical / galvanic isolators shall be used as required.

7.8.11 Panels, Cubicles and Enclosures

7.8.11.1 General

a) All panels, cubicles and enclosures shall be furnished complete with integral piping, internal wiring, convenience outlets, internal lighting, grounding, ventilation, space heating, vibration isolating pads, and other accessories.
b) Unless otherwise specified, cable entry for panels / desks / cabinets shall be through bottom via a glanding plate. A fireproof seal shall be used to seal the bottom to prevent the entry of dust.
c) Panels and cabinets shall be constructed from steel sheet reinforced as required to provide true surface and adequate support for devices mounted thereon. The thickness of the steel plate shall conform to the requirements of UL 50 or an equivalent standard. Panels and cabinets shall be of adequate strength to support mounted components during shipment and to support a concentrated load of 100 Kilograms on their top after erection.
d) Panel/ cabinet shall have an eyebolt on top for lifting.

7.8.11.2 Surface Preparation and Painting

Sheet metal exterior steel surfaces shall be sand blasted, ground smooth, and painted as specified below:

Suitable filler shall be applied to all pits, blemishes and voids in the surface. The filler shall be sanded so that surfaces are level and flat; corners are smooth and even. Exposed raw metal edges shall be ground burr-free. The entire surface shall be blast cleaned to remove rust and scale. Oil, grease, and salts, etc. shall be removed by one or more solvent cleaning methods prior to blasting.

a) Two spray coats of epoxy primer surfacer shall be applied to all exterior and interior surfaces; each coat of primer surfacer shall have a dry film thickness of 1.5 mil. A minimum of two spray coats of final finish color (Catalyzed epoxy or polyurethane) shall be applied to all surfaces of dry film thickness 2.0 Mil. The finish colors for exterior and interior surfaces shall conform to the following shades:

i. Exterior – RAL 7032
ii. Interior - Brilliant White.

b) Paint films, which show sags, cheeks, blisters, teardrops, fat edges or other painting imperfections shall not be acceptable.

7.8.11.3 Wiring

Wiring within the panels shall conform to NEC standards and shall be factory-installed and tested at the works. All interior wiring shall be installed neatly. Features shall not be limited to the following :

a) All spare contacts of relays, switches, and push buttons shall be wired up to the terminal blocks.
b) Each wire shall be identified at both ends with wire designation as per the approved wiring diagram. Heat shrinkable type ferrules with indelible computerized print shall be used with cross- identification.

c) Wire termination shall be made with an insulated sleeve and crimping type lugs. All external connections shall be made with one wire per terminal. Wire shall not be spliced or tapped between terminals. Open-ended terminal lugs shall not be used.
d) Internal wiring should be terminated uniformly on one side of the terminal block, leaving the other side available for termination of outgoing cables.
e) Analyzer measuring lead wires, or any other lead wires carrying measuring signal of the order of low millivolt or micro volt shall be electrically and physically isolated from other AC and DC wiring.
f) All low-level signal cables shall be separately bundled from control cable.

g) Wires shall be dressed and run in troughs with clamp-on type covers. Wires shall be neatly bunched in groups by nonmetallic cleats or bands. Each group shall be adequately supported along its run to prevent sagging or strain on termination.
h) Shield wires shall be terminated on separately.
i) Common connections shall be limited to two wires per terminal.
j) Wiring to door-mounted devices shall be provided with multi-strand wires of (49 strands minimum), adequate loop lengths of hinge-wire so that multiple door openings will not cause fatigue to the conductor.
k) Wiring shall be arranged to enable instruments or devices to be removed and/or serviced without disturbing the wiring. No wire shall be routed across the face or rear of any device in a manner that will impede the opening of covers or obstruct access to leads, terminals, or devices.
l) Panel internal wiring shall follow distinct color-coding to segregate different voltage levels, viz. 24V DC, 48V, 110V AC, 240V AC, 220V DC etc.
m) Panels, cabinets, and desks shall be provided with removable, gaskette cable gland plates and cable glands. Split-type grommets shall be used for pre-fabricated cables.
n) IPCEAS. The wire shall be a multistranded, annealed, flexible, high-purity copper conductor with heat-resistant FRLS PVC insulation and shall pass the vertical flame test per IPCEAS 1981.
o) Wire sizes used for internal wiring shall not be lower than the followings :

i. Control wiring (switchs, pushbuttons etc.)	:	1.5 Sq.mm
ii. Power supply/ receptacle illumination wiring	:	2.5 sq. mm or higher as per load.
iii. 4-20mA DC current and low voltage signal up to 48V DC	:	1 Sq. mm

p) Identification of conductors shall be done by insulation color-coding, as identified on drawings or printed wiring lists.
q) All cables terminated in the terminal block (both signal cables and power cables) shall be ferruled. Ferruling shall be double cross ferruling, i.e., source and destination addresses shall be marked on both sides of the tube ferruling.

7.8.11.4 Grounding

a) The system cabinet AC and DC grounds shall be electrically isolated from each other and also from the Instrumentation signal ground. All the above-ground shall be individually connected to a single point in the ground pit. A dedicated redundant earth pit shall be provided, which shall be away from the HV equipment. This earth pit shall not be shared with other electrical equipment grounds and shall also be insulated from other electrical system grounds to ensure single-point grounding of the system. The grounding resistance shall be less than 1.0 ohm. The IEEE guidelines shall be followed when designing the grounding system.
b) Panels and cabinets shall be provided with a continuous tinned copper ground bus bar of a minimum 25 mm x 6 mm cross section, extending along the entire length of the panel / desk / cabinet assembly. The ground bus shall be bolted to the panel structure and effectively ground the entire structure.
c) The panel/ desk/ enclosure/ JB ground shall have two (2) bolt drilling with GI bolts and nuts at each end to connect to GI/ copper flat ground riser by means of insulated copper ground cable of required cross section with lug.
d) Circuits requiring grounding shall be individually and directly connected to the panel ground bus.
e) For electronic system cabinets, the electronic system ground bus shall be similar but insulated from the cabinet and shall be separately connected to the system ground. Signal cable shields shall be grounded

at the panel end only and shall not be left open. The ground in between panels of a shipping section shall be firmly looped.

f) Electrical meters, relays, transmitters, and switching devices, operating at a voltage less than 50V, may be grounded through the steel structure.

7.8.11.5 Panel / Cabinet/ Desk/ Enclosures Environmental Protections

a) Panels, cabinets, desks, distribution boxes, terminal boxes, and all other field-mounted equipment/enclosures shall suit the environmental condition of the area and shall not be inferior to the requirement indicated in the following table:

Sr. No.	Location	Enclosure type
1.	Indoor type non-ventilated enclosure in non-hazardous area	IP-45
2.	Indoor type ventilated enclosure in non-hazardous area	IP -42
3.	Enclosure in Air-conditioned area	IP-22 with suitable canopy at top to prevent ingress of dripping water.
4.	Outdoor type in non-hazardous areas	IP-65
6.	Outdoor in hazardous areas	As per requirements of the NEC / IS Code for the location

b) The construction of electrical enclosures located in areas subject to conditions classified in the National Electrical Code (NEC)/IS Code as hazardous shall be of a type designated suitable for the environment in which they are located.

7.8.11.6 Terminal Blocks

a) Terminals shall be chromated galvanized, DIN rail-mounted, screwless cage clamp-type. Terminals shall have screwed connection for conductor cross-section above 2.5 mm2. Terminal blocks shall conform to IEC 947-7-1.
b) The characteristics of the terminal blocks shall be as follows.
i. High contact force, independent of conductor cross-section and large contact surface area.
ii. Self-loosening protection.
iii. Resistant to thermal aging and vibration.
iv. Low and constant voltage drop
c) Tension spring shall be made of high quality, non-rusting, acid-resistant steel. The current bar shall be of tin-lead plated copper or brass.
d) Terminals shall be of a non-flammable thermoplastic material such as polyamide.
e) Terminal blocks shall be mounted vertically in panels and cubicles with clearance for at least 100 mm between two sets and between the wall and the terminal block.
f) Terminal blocks shall be provided with white marking strips / self-adhesive marker cards. Power terminals shall have protection covers.
g) At least 30 percent spare, unwired terminals shall be provided for all panels, cabinets, desks, junction boxes, etc. This shall be in addition to 20% spare wired terminals for spare IO channels and 10% spare wired modules.
h) The bottom of the terminal block shall be at least 200 mm above the cable gland plate for bottom-entry type panels.

i) For extending a 24 V DC supply to panels, the size of the terminals shall be decided based on voltage drop and not based on a 24 V DC supply to panels, the size of the terminals shall be determined based on voltage drop, rather than current.
j) Other requirements of the terminal blocks are as follows.
k) The last block in a rail-mounted assembly shall be closed with an end plate and end bracket.
l) For visual and electrical separation of terminal groups, partition plates shall be provided,
m) which can be push-fitted after forming an assembly.
n) The design shall permit testing of incoming and outgoing signals using a suitable test plug and socket without requiring the disconnection of cable connections.
o) It shall be possible to use jumper plugs through the test plug socket to connect adjacent terminals.
p) Where more than one connection to a terminal block is required, two-tier terminals shall be used.
q) Terminal blocks shall be of different colors depending on voltage levels.

7.8.11.7 Nameplates and Labels

a) Each item shall have permanently attached to it, in a prominent position, a rating plate of non-corrosive material upon which is to be engraved the, equipment, type/model number, range, serial number, together with details of the loading conditions under which the item of plant in question has been designed to operate.
b) Such nameplates or labels are to be of white non-hygroscopic material with engraved black lettering, or alternatively of transparent plastic material with suitably colored lettering engraved on the back.
c) The nameplates shall be held by self-tapping screws. The size of the nameplate shall be approximately 20 mm x 75 mm for the equipment and 40 mm x 150 mm for the panels.
d) Items of plant such as valves, which are subject to handling, are to be provided with an engraved chromium-plated nameplate or label with engraving filled with enamel, suitably mounted or as fixed with a strong rustproof chain.
e) All such nameplates, instruction plates, lubrication charts etc. shall be in English .

7.9 Metering Bases And Chart Units

The following system of units shall be followed for various displays and scales unless otherwise mentioned:

i)	Pressure	:	Kg/cm^2
ii)	Differential Pressure	:	mm of H_2O column / Kg/cm^2
iii)	Draught	:	mm of H_2O column
iv)	Vacuum	:	Kg/cm^2 (abs)/ mm of Hg column
v)	Temperature	:	Degree Celsius (^{O} C)
vi)	Flow (Water)	:	Tonnes / hr, M^3/Hr
vii)	Flow (Oil)	:	M^3 / Hr, Liter/ Hr
viii)	Flow Air	:	Tonnes / hr / M^3 / Hr.
ix)	Density	:	gms / c.c.
x)	Level	:	Mm /%
xi)	Conductivity	:	Siemens / cm
xii)	Dissolved Oxygen / Silica / Sodium	:	ppm /ppb
xiii)	Turbidity	:	NTU
xiv)	Residual Chlorine	:	ppm
xv)	UV Transmittance	:	%

7.10 Process Connection & Instrument Hook Up

Instrument connection to the process system (piping, vessel, etc.) shall be according to the process and piping specifications up to and including the root valves. Root valves shall be installed as close as possible to the piping or vessel.
Each instrument shall have its own independent connection to the process, except for instruments located on a standpipe. Each instrument shall be connected independently to the standpipe through isolation valve.

Isolation and drain valves adequate for duty and capable of withstanding the continuous design condition of main process shall be provided. For process pressure equal or above 40 kg/ sq.cm double blowdown valves shall be used connecting to blowdown header. Instrument manifold / gauge valve shall be installed close to the instrument.

Process connections for instrument lines and vessels shall be in accordance with standards such as ASME or other recognized international standards. The table below indicates the type of connection generally to be used.

Instruments	Equipment / Pipe Side	Instrument Side
Level Instruments		
Internal Displacer	4" - Flanged	4" - Flanged
External Displacer	2" - Flanged	2" - Flanged
Level gauge	¾" -Flanged	¾" - Flanged
DP Type	½" (min.)-welded	½"- NPT
External cage Level switch	1"- welded	1"- welded
Flow Instruments		
DP Type	½" - welded in general	½" - NPT
Pressure Instruments		
Conventional	½" (min.)-welded	½" - NPT
Diaphragm type- Fuel Oil application	3"- Flanged	3"- Flanged
Temperature Instruments		
Thermowell	Generally - M 33 X2 (M) 1½" Flanged- For air path application	½" NPT
Analyzer		
Liquid analyzer	½"- 1" - welded	½"

Separate stubs and take-off points with thermowell / root valves shall be provided for performance guarantee test.

Impulse pipes shall be clamped at suitable interval not exceeding 1.5 meter. Process pipe shall not be used for supporting the impulse pipe.

Fittings shall conform to ANSI B 16.11. Threads of the piping component shall be of tapered construction.

The instrument blowdown header shall be no lower than the material grade ASTM A 106 Gr. C.

Impulse pipe shall be laid at least with slope of gradient 1:10 to avoid any air pocket or water accumulation.

Expansion loop shall be provided at the end of each termination.

Orientation of tappings shall be as follows:
a) For liquid service within 45 ^{O} at lower half of the pipe horizontal plane.
b) For air service within 90 ^{O} at upper half of the pipe horizontal plane.

As a rule tap orientation of high and low pressure side should be parallel and symmetrical.

Pressure & Differential pressure instruments in liquid services shall be located below the taps, and the piping shall be sloped to avoid the formation of an air pocket.

Pressure & Differential pressure instruments in air service shall be located above the taps, and the piping shall be sloped back to the process to avoid the formation of any liquid.

Impulse pipe including taps for coal mill application shall be provided with air purge connection. Differential instruments for such applications shall have continuous and intermittent purging. Whereas, pressure measurement shall have only intermittent purging.

Material of impulse pipe for the instruments mounted on the rack and enclosure shall be the same as that of the main process pipe, except for a stainless steel tube of Gr. 316H or better shall be provided for connection between the impulse pipe (from the tee connection on the impulse pipe) and the instrument manifold valve & instruments. Impulse pipes, tubes, fittings, and accessories shall have the same design pressure and temperature as the related main pipe.

A. Site Conditions

- Temperature and Humidity Range. The equipment shall be installed in an environment with a temperature range of 0°C to 55°C and a maximum relative humidity of 100% (non-condensing). The Contractor shall use, where required, fans, heaters, and air conditioning units to maintain a correct working temperature for his equipment. All Parts of the equipment shall be constructed of materials or treated to prevent the formation of mould, fungus or any corrosion over the temperature and relative humidity ranges specified.
- EMI/RFI Noise Immunity. The equipment to be provided shall be adequately protected against interference from the use of radio transmitters, at any point external to the equipment housings and no malfunction of the equipment shall result from this cause. Responsibility for the correct and reliable operation of the equipment rests with the Contractor, who must ensure that the equipment is adequately protected against the ingress of radiated, mains-borne, and signal-borne interference.
- Generated Interference. The Contractor shall ensure that the computer, instrumentation, and communications equipment conforms to BS EN 50081- 1 or equivalent Indian Standard for noise emissions.
- Coordination. The Contractor shall check with other trades to ensure that equipment and materials can be installed in the space provided. Provide other trades with the necessary information to execute their work. Details on Drawings, which are specific regarding dimensions and locations, are for information purposes. Coordinate with other trades to ensure work can be installed as indicated.
- Sequencing. The Contractor shall make applications to the local telecommunications Service Provider for the provision of communications and coordinate with the Sub-Contractor responsible for the installation of power supply services under this contract. Applications shall be made in time to ensure services are available for the installation and commissioning of the telemetry equipment.

B. Panel Details

I. Enclosures and mounting boards

Enclosures shall be any form of board, cabinet, panel, desk, box or case used to protect, contain or group instrumentation, telemetry or control equipment.

All equipment in or on enclosures shall be arranged logically and, as far as possible, symmetrically, with projections minimized. Each enclosure and board shall be designed on ergonomic principles and shall permit in-situ and safe access for any normal adjustment, maintenance and servicing. The tops of plant-mounted enclosures shall be sloped downwards from front to rear.

Enclosures mounted inside buildings shall have a minimum rating of IP 45 protection.
Enclosures for use outside buildings or in places where splashing may occur shall have a minimum rating of protection to IP 65 and have tops which project sufficiently to protect the vertical faces of the enclosure and any component mounted thereon from splashing, inclement weather, and direct sunlight. Additionally, when enclosures for use outside buildings are located in areas where exposure to direct sunlight will result in high top-panel surface temperatures, causing the internal temperature to exceed the manufacturer's recommendation (typically 40°C), the enclosure must include a sun shield fitted to the top of the enclosure. The sun shield shall prevent direct sunlight from reaching the instrumentation for the full day throughout the year, and shall have louvered ventilation.

All instrumentation, inclusive of analytical instruments (DO, ORP, Chlorine, Multi parameter online instruments, etc), irrespective of the transmitter IP Rating, shall be installed in IP-65 rated enclosures.

Fixing arrangements for surface-mounting enclosures shall be external to the enclosure and shall ensure that the rear face of the enclosure is not in contact with the surface to which it is fixed.

Enclosures shall have hinged access doors, fitted with recessed lockable handles.

Doors shall be of rigid construction and provided with close-fitting flexible seals in recesses to prevent the ingress of liquids, moisture, dust and vermin. Hinges shall be of the lift-off pattern and one hinge shall engage before the other for ease of fitting. Wherever necessary, removable access covers secured by quick-release fasteners shall be provided to ensure ease of maintenance for all installed apparatus.

Mounting plates, brackets and racks shall be provided for all other internal equipment which shall be hinged or otherwise arranged with quick-release fasteners or captive screws to give quick and easy access to equipment, securing screws, terminals and wiring.

Enclosures for two or more devices with electrical circuits shall have gland plates and terminal blocks as specified elsewhere.

Each enclosure shall be designed for the safe testing and servicing of equipment with the power on. Each part which may be live under any circumstances shall be so covered or shielded as to prevent inadvertent contact.

II. Panel design and construction

Unless otherwise specified, all instrument panels, instrument cubicles, control panels, control consoles and desks, associated equipment and terminal racks, telemetry and electronic equipment racks, and the like shall

be free-standing, floor-mounted units and shall conform to the requirements of this part and will hereafter be referred to as panels.

The design and dimensions of control consoles and desks shall be determined according to their intended function and shall be in accordance with the requirements of the Specification. The height shall not exceed 1400mm above the finished floor level.

Unless otherwise specified the height of panels shall be not greater than 2130mm overall (excluding lifting devices) above finished floor level. All panels shall have a minimum width of 900 mm and shall not exceed 2mtr in length in any case

Controls, switches and push-buttons shall be positioned below or adjacent to any associated reading instrument. Panels for use in locations such as pumping stations and machinery rooms shall have anti-vibration mountings.

The clearance between the extremities of apparatus mounted on the internal walls shall allow safe and unobstructed access to all terminals and to parts requiring maintenance.

Panel layout drawings shall normally include a list of all instruments, accessories and components contained therein. If the drawings have insufficient space for the list, a separate schedule of instruments, accessories and components shall be provided and the panel drawing shall contain a cross reference to the contents list and an indication of the panel location of each item on the list.

III. Panels - Major

Panels shall be constructed generally as specified in the preceding clause. Panel material shall be prime-quality, cold-rolled and annealed mild steel or zinc-coated mild steel sheet, suitably braced and stiffened as necessary with flat bar or angle to form a rigid structure.

Panel fronts shall be flat and free from bow or ripple. Exterior corners and edges shall be rounded or welded and ground to give a smooth overall appearance.

Flanged edges shall be straight and smooth.

Materials shall be chosen with due regard to the panel size, number of cut-outs, instrument weight and position of centre of gravity and method of fabrication, with the following minimum thickness:

- instrument bearing surfaces, gland plates and pneumatic distribution plates, 3mm;
- internal mounting plates, 3mm;
- doors, covers and filler panels, 3mm as a minimum.

No design involving the use of externally-visible assembly or fixing bolts and screws or any design resulting in dust or water-collecting crevices will be accepted.

When a panel is constructed in sections, the sections shall be designed for ease of assembly during installation and, in any case, shall not exceed 2m in length. All panels shall have a minimum width of 900 mm and shall not exceed 2 m in length in any case. All necessary nuts, bolts, washers and the like shall be supplied and included in the same shipment as the relevant sections. Sections exceeding 1m in length shall be provided with double doors.

Each panel shall be mounted on a self-draining base frame fabricated from 150 mm deep, steel channel section which shall be drilled or provided with clamps for bolting to the floor. The base frame shall be set back from the panel's front face to provide a toe space of at least 25mm. The outside of the base frame shall be covered with an approved kicking strip.

Ceiling and other filler panels shall be fabricated from sheet steel and adequately stiffened. Each section shall have 50mm returned edges along all four sides and shall be braced to the main steelwork of the panel.

A chequer-plate floor shall be provided inside and above the level of the base frame, having openings suitable for the bottom entry of cables when applicable.

Sufficient removable un-drilled gland plates, in sections convenient for handling, shall be fitted close to the appropriate terminal blocks and not less than 230 mm above the panel floor or not less than 230mm below the panel top. The gland plates shall have removable side covers, providing access to both sides of the gland plate and ensuring a vermin-proof and dust-proof construction. Gland plates of a surface mounted enclosure may form a part of the base or top.

Panels containing instruments that use a fluid as the transmission medium shall have distribution plates with bulkhead unions for terminating internal and external pipework.
All doors shall open outwards and all doors in one panel assembly shall use the same lock and key combination.

The panel design shall ensure adequate ventilation and air circulation, while preventing the entry of vermin or dust. Panels installed in control rooms or other clean condition areas shall have louvres to allow air circulation. Temporary closures shall be provided to prevent the entry of dust and vermin during transit and installation. After commissioning has been completed, all entries except air circulation louvres shall be sealed.

No equipment other than front-of-panel items shall be mounted on panel wall surfaces.

If electrical and non-electrical instruments are mounted in the same panel, the panel shall be subdivided internally to separate the electrical and non-electrical sections.

All connections shall be arranged to ensure that no accidental damage to cabling or electrical components can occur in the event of failure of any non-electrical component or connection.

Provision shall be made for safe and easy handling during transit and installation.

If lifting eyes are provided, they shall be reversible and panel tops shall be reinforced where necessary.

Where equipment is specified to be installed at a future date, space shall be allocated, and cut-outs with removable masking plates, brackets, supports, wiring, terminals and piping and the like shall be provided.

Panels shall be finish-coated at the place of manufacture before commencing the installation of apparatus and other fittings.

IV. Panels – Minor

Panels for installation on the Plant, which contain relatively few items of equipment, or where specified elsewhere, shall be classified as minor panels and shall be constructed generally as specified in the preceding clause, complying with this Clause.

Panels shall be fabricated from sheet steel less than 3 mm thick, suitably braced to form a robust and rigid structure. Exterior corners and edges shall be rounded to give a smooth overall appearance and assembly bolts, screws or rivets shall not be visible on the front face.

The design shall ensure adequate ventilation and air circulation where required, without permitting the entry of vermin. Openings for cables shall be made vermin-proof. Doors shall be hinged and shall be provided with close-fitting flexible seals in recesses to prevent the ingress of liquids, moisture, dust and vermin. Unless otherwise specified, panels shall be suitable for floor mounting and shall not exceed 2130 mm in height. Where surface-mounted panels are provided, the fixing shall prevent the ingress of moisture, and the rear of the enclosure shall be at least 10mm from the wall.

Lifting eyebolts shall be removed, issued to the Purchaser and subsequently replaced with bolts after installation.

Panels shall be extensible, and symmetrically arranged as far as possible with projections kept to a minimum. Where two or more panels are fitted together, they shall form a flush-fronted continuous panel of uniform height. Front door and top cover dimensions shall match. Instruments, relays, and control devices shall be mounted at a height not more than 2000mm and not less than 300mm from floor level.
The arrangement of equipment within each enclosure shall permit easy access for installation and maintenance. No instruments, relays or other components shall be mounted on rear access doors or removable covers.

V. Panel Protection

Adequate facilities for isolation and protection by miniature circuit breaker or fuse for each instrumentation and control circuit and sub-circuit shall be provided and shall be so arranged that any interruption causes minimum disruption of plant, operates the appropriate alarm and cannot result in any unsafe operating condition.

All fuses shall be of the cartridge pattern and main fuses shall be of the high rupturing capacity type. Fuse and solid-link carriers and bases shall be of plastic molded insulating material of an approved make. Ceramic materials will not be accepted. Live connections shall be efficiently shrouded and it shall be possible to change fuses with power on without danger of contact with live metal. The fuses shall be rated to give maximum protection to the equipment in the circuit, and the rating shall be permanently inscribed on the fuse label and on the fuse carrier. Unless necessary for the protection of particular equipment, miniature circuit breakers used for individual circuits in a panel or control desk shall not trip on over-voltage or under-voltage.

Bases for solid links shall not be interchangeable with those for fuses. Fuses and links in the same circuit shall be mounted opposite each other in separate, adjacent rows, and shall not be alternated in the same row. At least 20% and no fewer than two unallocated miniature circuit breakers, fuses, or links shall be provided in each panel distribution board. Miniature circuit breakers and fuses of similar size and rating shall be of the same make and type.
At least 30%, and not less than two, spare fuses and links of each rating shall be provided and fitted in clips inside the panel.

Each instrument requiring a power supply shall be individually wired and protected so that, in the event of a failure in one circuit, the remainder is unaffected. Power supply circuits shall be of sufficient rating that any protective device may operate without reducing the voltage at the terminals of any other component to an unacceptable level.

VI. Panel isolation

Clearly-labelled isolating circuit breakers shall be provided for each incoming power supply. Switches shall be of the quick make-and-break type with spring loaded contacts that close fully without requiring full operation of the handle. The handle and cover shall be interlocked so that the handle cannot be operated when the cover is open and the cover cannot be opened unless the switch is in the 'off' position. The 'on' and 'off' positions of each switch shall be indicated clearly.

Circuit breakers for panel power supplies shall be mounted near an access point and in positions that allow them to be operated easily from a standing position.

Plug-in isolating links or devices of an approved type shall be provided in any circuit that may still be live when the power supply isolators are in the 'off' position, as, for example, in circuits controlling equipment whose power supply is independent of the panel. Such links or devices shall be properly screened and, if not incorporated in or adjacent to their associated outgoing terminals, shall be labeled with suitable warning notices.
Any item of panel equipment to which panel internal wiring is connected with a plug and socket instead of terminals shall be wired in the flexible cable of adequate rating between the 'free' plug and a socket mounted adjacent to the device.

The power supply connector shall be a socket.

VII. Panel terminal blocks

External wiring for panel power supplies shall be terminated on the appropriate isolator. Signal cables from strain gauges, analyzers, resistance thermometers, retransmitting slide-wires, and thermocouples may be terminated at their appropriate instruments.

A terminal block shall be provided as the interface between the corresponding conductors of each internal and external wire and each internal and external connection except those listed above. The terminal blocks shall be mounted vertically where possible and not nearer than 230mm to the floor or less than 230mm from an incoming cable gland.

Terminal block rows shall be spaced apart by at least 150mm and arranged to permit convenient access to wires and terminals, and to enable ferrule numbers to be read without difficulty.

Other circuits shall be grouped on the terminal blocks according to the classification given in the clause for 'Panel internal wiring' which shall be clearly marked along the corresponding section of each terminal board. Groups of different voltages on the same board shall be separated by insulated barriers.

All connections shall be made from the front of terminal blocks and no live metal shall be exposed at the back. All terminal blocks shall be of the type which clamps the wire securely and without damage between two plates using a captive screw and which permits removal of any terminal without disturbance to adjacent terminals. Pinch-screw type terminal blocks will not be accepted. Terminal moldings shall be in melamine to BS 1322, polyamide or equivalent. Terminal rails shall be hot-dip galvanised. Current bars between the

two connection points of each terminal block shall be of copper or brass with tin/lead alloy plating. All steel parts shall be zinc-plated and passivated with a yellow chromate layer. Terminal blocks for input and output analogue signals and for circuits containing volt-free contacts internal or external to the cabinet shall be of the clip-on type SAKC or equivalent, which permit the connection of a test millimeter or continuity meter without disconnecting any wiring. Terminal blocks for power supplies for equipment external to the panel shall permit the isolation of the item of external equipment without affecting the operation of any other circuit within or outside the panel.

No more than one core of external cables or two internal wires shall be connected to any terminal. If terminal blocks are used as common points for two or more circuits, individual terminals with the appropriate number of permanent cross connections shall be provided. The lengths of exposed cable cores shall be sufficient to reach any terminal in the appropriate row or rows. The cores shall be formed into a neat loom and a separate loom shall be provided for each cable.

Each row of terminal blocks shall contain at least 20% spare terminals over the number required for terminating all cores of external cables in that row. Unless otherwise specified, each external cable shall contain at least 20% spare circuits, with a minimum of one spare circuit.

Terminal blocks shall be numbered consecutively in a sequence that is different from the one used for identifying wiring. The terminal numbers, voltage grouping, and terminal board layout must correspond precisely with the wiring diagrams, allowing for quick and accurate identification of wiring.

All terminal boards shall be provided with covers made of transparent insulating material that does not sustain combustion and shall be sectionalized where possible, allowing access to groups of terminals without requiring the uncovering of all boards. Terminals that may be live when the panel is isolated from its main supplies shall be suitably labelled to minimize the risk of accidental contact.

VIII. Panel internal wiring

Panel circuits shall be segregated into the following categories:

Group 1: Power control and very-high-level signal wiring (above 50V):
1.1 ac power supplies;
1.2 dc power supplies;
1.3 ac current signals above 50mA (such as CT circuits);
1.4 ac voltage and control signals above 50V (such as PT circuits).

Group 2: High-level signal wiring (6V to 50Vdc):
2.1 signals from conventional electronic transmitters and controllers (such as digital or 4mA to 20mA);
2.2 circuits to alarm annunciators and other solid-state devices
2.3 digital signals;
2.4 emergency shut-down and tripping circuits;
2.5 on/off control circuits;
2.6 intrinsically safe circuits;

Group 3: Low-level signal wiring (5V dc and below):
3.1 signals from thermocouples;
3.2 signals from resistance thermometers and re-transmitting slide-wires;
3.3 signals from analytical equipment and strain gauges.

For Group 3 wiring, internal connections to the instruments shall be made by one of the following methods:

(a) The twisted, screened conductors of the external cable shall be led direct to their appropriate instruments via ducting systems installed for this purpose during construction of the panel;

(b) The conductors of the external cables shall be terminated on terminals segregated from all other categories and the connections to the appropriate instruments shall be made using twisted pairs with individual screening installed for this purpose during construction of the panel.

Internal wiring for all circuits in Group 2 except those sharing a common connection shall be multi-stranded, twisted pair, 0.75 mm² minimum copper conductor with HPDE or PVC-insulated cable of adequate grade and rating.

Wiring for circuits in other Groups or sharing a common connection shall be run in stranded, 1.0mm² minimum copper conductor with 250V grade, PVC-insulated cable of adequate grade and rating.

Wiring sheath colors shall be black for ac circuits, and grey for dc circuits (excluding thermocouple circuits) and blue for Group 2.6 circuits. Circuits supplied at 240V, between 240V and 110V dc shall also be physically segregated from each other and from other circuits. Access to wiring and components of circuits with voltages exceeding 240V shall not be possible unless the circuit has been isolated.

Separate ducts, trunking, cable looms, tray work and the like shall be provided within the panel for each category with at least 150mm between parallel paths of Group 1 and those of any other Group. Intrinsically safe circuits and their terminals shall be segregated from other circuits and terminals.

All wiring shall be neatly and securely fixed by insulated cleats, bunched and secured by approved insulated wiring trunking or non-corrodible flexible tubing. Not more than **75%** of the capacity of trunking, ducts, looming, or tubing shall be used. Insulated earth wiring shall be so arranged that access to any equipment or connection point or the removal of any item of equipment is unimpeded.

Wiring for future equipment shall be secured and terminated on terminal blocks. Lacing for wiring looms shall be of rot-proof cord or plastic strips. Inter-section wiring in multi-section cabinets shall be via a terminal block in each section.

IX. Panel wiring identification and termination

Identification ferrules shall be fitted at both ends of each wire. The numbers or letters used shall correspond with the appropriate wiring diagram. The ferrules shall be of plastic insulating material with permanent black characters on a color coded background for numbers and on a white background for letters, unaffected by oil or water. They shall be so arranged that they can be read logically from left to right when viewed normally.

The system of wire identification shall be such that wires in the same circuit on opposite sides of a terminal shall have the same reference, and this system shall be continued through all external cabling.
Terminal ferrules (spade, tongue, crimped connections) shall be provided on each conductor.

X. Panel Earthing

A continuous copper earth bar, with a cross-section of not less than 25mm x 6mm, shall run the full length of each panel and be securely fixed and electrically bonded to the main frame. The cable gland-plates and the earth bar shall be provided with suitable brass terminals of not less than 6mm diameter for connecting the metal cladding or armoring of all incoming and outgoing cables to the station earthing system.

A second continuous copper earth bar of not less than 25mm x 6mm cross section, electrically isolated from the steelwork of the panel and metal cladding and armouring of cables, shall be provided for earthing the signal earth connection of each instrumentation and control device and the screen(s) of each instrument cable not earthed elsewhere to the station instrumentation earth plate. The earth bar shall have sufficient brass terminals as specified above for each instrumentation and control device and the screen of every shielded cable plus 25% spare terminals.

In multi-section panels, each earth bar shall be electrically bonded to the corresponding bars in the adjacent section(s).

The earth pit for the instrumentation system shall be separate. Electric earth pit shall not be used for earthing of instrumentation equipment. All signal cable screens (analogue and digital) shall be terminated onto the instrument earth bar. Signal cable screens shall be earthed at the control panel end only. Screens at the field end shall be tied back and insulated.

SPD s associated with the control and instrumentation system shall be earthed to the instrument earth in accordance with the SPD manufacturer's recommendations.

XI. Panel lighting

Each panel shall be adequately illuminated internally, as evenly and as free from dazzle as possible, by fixed LED lighting controlled from totally-enclosed light switches and by totally-enclosed door-operated switches positioned so as not to interfere with access. The control switch for an inspection lamp shall form part of the lamp assembly. Lighting circuits shall be fused independently of any instrumentation and control circuit and designed to allow lamps to be replaced safely and shall be fed from a distribution board and circuit breaker connected on the live side of the main panel ac supply circuit breaker.

XII. Panel ventilation

Each panel shall be provided with ventilation fans to ensure that equipment within the panel is maintained within manufacturer's recommendations, with due regard to the environment in which the panel will be mounted. Fans shall be controlled by a suitably labelled enclosed switch mounted internally in an accessible position.

Fans shall be mounted with their axes horizontal and shall be arranged to draw clean air into the panel. Air entries shall have filters that can be renewed from outside the panel and shall be designed to prevent the entry of rain, spray, injurious fluids, sand or dust.

XIII. Panel labels

All control gear shall be fully labelled, identifying the equipment designation/function, all external and internal components, all rating data, detailed equipment operating data and for danger and hazard warning.

Labels shall be provided for every panel to describe the duty or otherwise identify the panel and its sections and every instrument, component and item of equipment mounted internally and externally. Where applicable, front-of-panel labels shall be as detailed in the Specification. Wording shall be clear, concise and unambiguous and shall be subject to review by the Employer Representative before manufacture. Each label shall be permanently secured to the surface near the item to which it refers. Externally-fitted labels shall be of Perspex or other approved transparent plastic, with letters and numbers rear-engraved and filled with black.

The rear surface of each Perspex label shall be finished with a coat of paint of the same colour as the panel external finish. Instrument duty labels fitted externally shall be below the item to which they refer. Embossed tape or similar adhesive labels will not be approved.

Rear-engraved and filled plastic shall be used for internally fitted labels, which shall be white with engraved black letters.

Labels conforming to the requirements of the preceding paragraphs or other approved means shall be provided:

- To describe or identify circuits or circuit components;
- To identify dc polarity;
- To warn or remind about dangerous or potentially-dangerous circumstances;
- Wherever elsewhere specified.

Unless otherwise specified, all engraving shall be in plain block letters, minimum 4mm high.

The minimum practicable number of different sizes shall be used.
Note: Contractor shall note that Manufacturers' nameplates shall not be fitted on panel external surfaces. Only equipment Tag I.D shall be located on the panel exterior surface. The same is applicable for filed junction boxes, panels, enclosures, etc.

XIV. Panel finish

All panels, desks, and cubicles shall be hard, smooth, durable, and finish-free of blemishes, shall be provided. Before painting, all external welds and any rough areas shall be smoothed, and all surfaces shall be thoroughly cleaned and free from scale, contaminants, corrosion, or grease. If rust-proof or Zintec steel has not been used in the construction, the panel shall be treated with a passivating agent such as phosphoric acid. All internal surfaces shall have a minimum of three coats of paint, of which the first shall be an approved anti-rusting priming coat and the final coat shall be an opaque, gloss-white enamel. All external surfaces shall have not less than five coats of paint of which the first shall be an approved etch-priming coat, and the second and third suitable undercoats, all of which shall be rubbed smooth when dry before application of the next coat. The undercoats shall be easily distinguished in shade or colour from the priming and finishing coats. The two final coats shall be of stove enamel paint, gloss or semi-matt finish, to a colour and finish to be advised by the Employer Representative. Stoving shall be carried out in accordance with the recommendation of the paint manufacturer.

The overall dry film thickness (DFT) shall be between 85 and 120 microns.

Nuts, bolts, washers and other fixing devices which may have to be removed for transit or maintenance purposes shall be galvanized or otherwise finished to an approved standard.

C. Instruments and ancillaries

I. General

All instruments, gauges and control equipment which perform similar duties shall be of uniform type and manufacture throughout the Works in order to facilitate maintenance and the stocking of spare parts.

All equipment shall be fully tropicalized and suitable for the worst environmental operating conditions. Panel-mounted instruments shall be of the electrically operated flush mounted type and shall have damp-proof and dust-proof cases.

Instruments mounted outside instrument panels shall have weatherproof and dustproof cases. Instrument cases shall be made of corrosion-resistant material or have a corrosion-resistant finish.

Instrument screws (unless forming part of a magnetic circuit) shall be of brass or bronze. Access to terminal compartments of instruments mounted outside panels or other enclosures shall not expose any working part. Moving parts and contacts shall be adequately protected from the ingress of dust. Where applicable, instruments shall be easily withdrawable from their housing for maintenance without interrupting their signal.

Unless otherwise specified, instruments shall be finished in the manufacturer's standard colour. Instrument dials shall be made of such material that no peeling or discoloration will occur with age under tropical conditions.

Plant-mounted indicators and gauges shall be sized to give full legibility when viewed from a position with convenient and easy access or from the point at which any operation requiring observation of the gauge is performed. The minimum diameter for any gauge shall be 100 mm, except where forming part of standard instruments and accessories, such as air sets.

Dials and bezels shall be of bronze and internal components shall be of stainless steel, bronze or other corrosion-resistant material.

Unless otherwise specified, all functions shall be transmitted electrically and all analogue signal-transmission systems shall be in accordance with BS 5863: Part 1 or equivalent and shall use a signal of digital or 4mA to 20mA DC. Where possible, measuring systems shall be designed so that any necessary power supply is taken from the appropriate instrument panel.

Transmitting devices shall have integral indicators to monitor the output signal or connections suitable for use with a portable test meter, and shall be capable of meeting the performance requirements specified in the appropriate part of BS EN 60770- 1 or equivalent.

Equipment mounted in enclosures shall be suitable for continuous operation at the maximum internal temperature possible in service, due account being taken of internally-generated heat and heat dissipated by other plant. All components shall be rated adequately, and circuits shall be designed so that a change of component characteristics within the manufacturer's tolerances shall not affect the performance of the plant. All equipment shall be designed to operate without forced (or fan) cooling.

Equipment provided with anti-condensation heaters shall be capable of operating without damage if the heaters are left on continuously. Unless provided with unalterable factory-configured ranges, measuring instruments shall have zero and span adjustment.

Field-mounted instruments shall be mounted such that they are easily viewable and easily accessible for maintenance. An access platform shall be provided for all instruments, which shall be mounted at a height to enable plant operators to access the same for reading and maintenance purposes.

Instruments not mounted in panels shall be supplied complete with all brackets, stands, supporting steelwork, and weatherproof IP-65 enclosures (separate from the instrument cases) necessary for securing them in their working positions and affording complete protection at all times, including periods of servicing, adjustment, calibration, and maintenance.

Each installation shall incorporate a valve and pipework for obtaining a sample representative of the fluid at the position of the permanent meter and drain. If the measuring and sampling points are remote from each other, the test and sample facilities shall be provided at both points.

In order that maintenance and inspection may be carried out safely and conveniently instruments mounted in elevated and open work areas shall be provided with safety ladders and a sufficiently sized working platform with sun shading.

D. Junction Boxes

I. Junction box (Instrument)

1	Construction	-	UV-resistant plastic
2	Protection	-	IP 65
3	Paint and shade	-	Powder-coated light grey as per Shade 631 of IS:5
4	Terminal strip	-	Elmex type capable of Terminating 0.5 sq.mm to 1.5 sq.mm Cable DIN rail mounted
5	No of terminal strips	-	30/40/70 Rating: 600v 10 a ac
6	Conduit & cable entry	-	Bottom side
7	Gland plant thickness	-	3mm
8	Door of JB	-	Hinged with proper locking Arrangement to avoid entry of Dust & moisture the design of Fixing screws of the lids of the Junction box shall be such that They do not come out of the lids When completely unscrewed (captive screws)
9	Dimension	-	Vendor to provide most Economic dimension of JB based On the no of Terminal bases and cable Entry
10	Mounting	-	Frame mounted
11	Earthing	-	Two no of earthing bolts for JB Earthing separate instrument Earth bus on insulating clits to be provided
12	Name plates	-	To be provided material: white Engraved letters on black Anodized aluminum sheet Fixing: stainless steel screws Lettering:- black with white Engraved. Note: No vendor nameplate shall be affixed to the junction box (exterior, interior)

II. Junction box (power & control)

1	Construction	-	UV-resistant plastic
2	Protection	-	IP 65
3	Paint and shade	-	Power coated light grey as per Shade 631 of IS:5
4	Terminal strip	-	Elmex type capable of Terminating 0.5 sq.mm to 1.5 sq.mm Cable DIN rail mounted
5	No of terminal strips	-	30/40/70
6	Conduit & cable entry	-	Lower side
7	Gland plate thickness	-	3mm
8	Door of JB	-	Hinged with proper locking Arrangement to avoid entry of Dust & moisture the design of Fixing screws of the lids of the Junction box shall be such that They do not come out of the lid When completely unscrewed (captive screws)
9	Dimension	-	Vendor to provide most Economic dimension of JB based On the no of Terminal bases and cable Entry clearly specifying GA Drawing
10	Mounting	-	Frame mounted
11	Earthing	-	Two no of earthling bolts for JB Earthing
12	Name plates	-	To be provided material: white Engraved letters on black Anodized aluminum sheet Fixing: stainless steel screws Lettering:- black with white Engraved. Note: No vendor nameplate shall be affixed to the junction box(exterior, interior)

E. Cabling

I. Instrumentation Cabling

Cables from conventional measuring transmitters and analogue process controllers, such as digital or 4mA to 20mA DC output from a constant-current source, (hereinafter referred to as high-level signals) shall be polyethylene or PVC insulated with stranded conductors. Each cable shall have an overall screen of braided copper or mylar backed aluminium foil giving a minimum coverage of 85%, a steel wire armouring insulated from the screen and from any ducting and an overall PVC sheath. For runs exceeding 30 metres or for all inputs to a data logger, computer or microprocessor, multi-core cables shall have an individual screen of braided copper or mylar-backed aluminium foil for each signal pair. The minimum conductor size shall be 24/0.2 mm but shall be of greater cross-sectional area if required for the satisfactory operation of associated plant. Cables for intrinsically safe systems shall comply with BS 5308 and the relevant certificate.

Cables from strain gauges, analyzers and the like, such as 0 to 100mV (hereinafter referred to as low-level signals — see also below) shall be as specified above and shall have an individual screen for each signal pair.

Cables from indicating devices to alarm or tripping circuits shall be as specified above for high-level signals but shall use cables, cable trays, ducts and conduit separate from those for other high-level circuits.

Cables for high-level signals, low-level signals, resistance thermometers and thermocouples shall be segregated from each other and each shall be separated from cables for power, communications and other electrical services. Other cables run in the vicinity of instrumentation cables shall be separated from instrumentation cables by a distance of not less than 300mm.

Initiating devices for plant protection and personnel safety shall be connected by individual cables direct to the tripping or safety device and shall not be routed via any intermediate junction, marshalling box, cabinet, relay or similar. The outer sheaths of such cables shall be coloured orange.

II. Fiber Optic Cable

If cable sizes are not indicated on Drawings or in schedules, determine the correct size based on total end-to-end signal attenuation not to exceed 40 dB, including all splices and termination losses, and after taking into consideration.

a) Type of fiber
b) Ambient conditions
c) Method of installation
d) The disposition of each cable relative to others

All cables and wires shall be suitable for installation and continuous services in the ambient conditions described elsewhere in this document.

Shop Drawings and Product Data shall be submitted for the approval of the Engineer as follows:

- Submit full technical details of each type of cable proposed.
- Submit copy of test certificates from the manufacturer
- Submit exact route of the cable run and relevant sections in the shop drawings.

Each drum length of cable shall be allotted a distinct and separate reference number. This number shall be indicated in the test certificate covering the respective length of cable and shall also be marked on the cable drum.

The Contractor shall advise the Employer Representative upon delivery to the site of each drum length, quoting the reference number. The test certificates shall be handed to the Employer Representative for examination and approval.

All cables shall be delivered to the site with the manufacturer’s seals, labels or other proof of origin intact. These labels and seals shall not be removed until the cable is required for use and shall be retained for inspection by the Employer’s Representative.

The Contractor shall be responsible for offloading and handling the cables on site and shall ensure that the cables are delivered to the site on drums and properly protected against mechanical damage. Where lengths are cut from cables, the open ends shall be sealed.

The Contractor shall be aware of the need to supply and install all cables for this Contract that are most suitable for the special environmental conditions prevailing in this project.

The cable shall comprise 6 fibers, loose tube, two fibers per tube with a central 1.5 mm nominal steel strength member, moisture barrier, steel tape armored in continuous lengths up to a maximum of 6.0 km or as dictated by cable joint chamber locations and route survey.

Single Mode	
Core Diameter	9.0 ± 0.5 micro m
Cladding Dia	125 ± 2.0 micro m
Coating (outer) Diameter	250 ± 15 micro m Material UV curable acrylate
Numerical aperture	0.11 micro m
Attenuation	<0.4 dB/km @ 1300 nm <0.2 dB/km @ 1500 nm
Bandwidth	1000 MHz @ 1300 nm
Chromatic Dispersion	3.5 ps/nm x km @ 1300 nm 20 ps/nm x km @ 1500 nm
Operating temperature range	-30 to +80 deg. C
Crush resistance	>200N/cm
Weight	500 kg/km (maximum)
Tensile strength	2000 N (minimum)
Multimode	
Type of fiber	Multimode, doped silica
Core Diameter	62.5 ± 3.0 micro m
Cladding Diameter	125 ± 2.0 micro m
Coating (outer) Dia	250 ± 15 micro m Material UV curable acrylate
Numerical aperture	0.275 $\pm$ 0.15 micro m
Attenuation	<3.2 dB/km @ 1300 nm <0.9 dB/km @ 1500 nm
Bandwidth	500 MHz x km @ 1300 nm
Operating temperature range	-30 to +80 deg. C
Crush resistance	>200N/cm
Weight	500 kg/km (maximum)
Tensile strength	2000 N (minimum)

III. Cable Termination Boxes

Cable termination boxes shall have double-ended screw terminals with removable links to facilitate core isolation during testing. Each box shall contain sufficient terminals for every conductor plus 20% spare terminals. Cable termination boxes shall have cable sealing chambers and insulated glands with earthing terminals, allowing the armouring to be earthed or isolated from earth, as circumstances dictate.

Termination boxes for use within buildings shall be of sheet steel with hinged or removable front covers. All other termination boxes shall be constructed of cast steel or heavy-gauge sheet steel, providing protection to IP55. All termination boxes shall be hot-dip galvanised or approved equivalent finish. Each terminal box shall have a removable, un-drilled gland plate and the Contractor shall supply and fit the requisite number of cable glands.

At each cable termination box, each cable core (including spares) shall be identified by a numbered slip-over type collet. The numbering for a particular cable core shall be the same throughout its length.

Cable joints shall be at points approved by the Engineer.
Each cable joint shall be of the straight-through type. The conductors shall be ferrule-jointed with the insulation maintained by heat-shrink sleeving. Joint closure shall be made with epoxy resin and the completed joint shall be impervious to water if submerged or in waterlogged ground. If cast iron joint boxes be used, they shall be provided with cable glands and, after installation and testing, shall be covered with Densomatic HD compound or equal; so that all sharp corners, bolts and projections are moulded to a smooth surface. Two lappings of Densopol grade ZN 50mm tape, or equal, shall then be applied overall. Jointing shall be carried out on each conductor, including any provided over the minimum quantity specified. All materials and things of every kind required for the cabling jointing shall be provided by the Contractor.

IV. Cable labelling

At the end of each cable, in a uniform and visible position, a label shall be affixed to the cable to indicate the site cable number, route, number, and the size of conductors. Labels shall be made of brass, aluminium, lead or copper strip, engraved and retained by suitable non-rusting or non-corrodible binding wire passing through two fixing holes, one at either end of the label. If the cable gland is not normally visible, then the label shall be fixed inside the panel by means of screws.

Three-phase power cable cores shall be identified as A, B, C or colour-coded red, yellow, blue so that the correct three-phase sequence is preserved throughout the system. Single-phase power cable cores shall be colour-coded red and black.

Control cables shall have individual cores identified through suitable permanent ferrules bearing the same number at both ends. Core identification shall occur at every point of termination using an approved system of colour-coded ferrule markers. The size of these ferrule markers shall be such as to match the overall diameter of conductor plus insulation. Numbering shall read from the termination upwards on all cores.

Each cable and core shall bear the same number at both ends of the cable and core, respectively.
a) Power terminations - colour, number or letter.
b) Control terminations - letter or number or both.

V. Cable terminations

All Polyvinyl chloride(PVC), Steel Wire Armoured (SWA) PVC and Cross Linked Polyethylene (XLPE) cables shall be terminated with mechanical glands which shall comply with BS 6121. They shall seal the inner and outer cable sheaths against ingress of dirt and moisture and provide adequate mechanical support. Each cable gland shall be protected by corrosion-resistant moulded PVC hoods, covering the entire assembly from the overall sheath to the gland neck.

Glands for armoured cables shall provide a positive armour clamp to the enclosure so that no tension is applied to the termination. The clamp shall also provide a high level of earth continuity and be of adequate size to withstand the full fault current of the system for one second.

All glands shall be provided with an earthing tag. For cables of 4mm² or less, a serrated washer may be used instead for earth continuity.

The cable termination and sealing equipment shall be obtained from the cable manufacturer, or approved supplier, and shall be purpose-made for the type, size and grade of cable concerned. The application of these materials shall be strictly in accordance with the manufacturer's instructions.

Through joints shall be permitted only on long cable runs outside buildings. Where such joints are necessary, the cables shall be jointed with epoxy or acrylic resin Cold-setting compound, which has been pre-measured and pre-packed ready for use.

The boxes shall be of a split-moulded plastic type with filling vents for the compound.

Bonding straps shall be fitted with armour clamps across the joint and inspected by the Employer Representative prior to filling the box with compound. Wrapped pressure-type joints shall not be accepted.

Conductor cores shall be jointed by number or by colour.

VI. Cable installation-general

Cables which are to be run on walls, ceilings or other building structures shall, unless otherwise agreed by the Employer Representative, be secured on cable trays and ladders or enclosed in conduit or trunking.

Every cable shall be neatly run vertically or parallel to adjacent walls, beams or other structural members. Cables shall not be installed in areas of direct sunlight.

Where this is unavoidable, approved sun shields shall be supplied and installed.

Where the building structure incorporates purpose-built covered duct or trench systems for main cables, instrumentation cables shall be segregated and installed on tray work or otherwise secured to the sides of the duct or trench.

Where the structure incorporates general service ducts or trenches containing pipework, chemical lines and other services, all cabling shall be segregated from the other services and shall be run on the walls unless otherwise agreed by the Employer Representative.

Cables shall be spaced to prevent interference between power and signal cables, and to avoid unnecessary crossovers.

The spacing of clips, saddles, and cleats shall prevent cable sag during their installed life. The method of fixing clips and the like shall be through non-corrodible screws inserted into approved wall fixings, such as rawplugs.

Cable hangers, cleats, saddles, brackets, and similar supporting devices shall be of an approved type and of adequate strength to support the cables they are designed for. They shall be treated to withstand Site conditions without corroding. Self-locking plastic buckle clips and strapping shall not be used. The arrangement and fixing of each cable shall permit the removal and replacement of any cable without disturbing any other cable or its fixings.

When cables are terminated in any particular item of equipment, special care must be taken to ensure that the cables approach the equipment from a common direction and are individually terminated in an orderly and symmetrical manner.

Submissions which the Contractor shall submit the following in relation to cable installations in addition to submissions detailed elsewhere in the Specification.

VII. Drawings and schedules:

- Block diagrams to show control cabling systems with each cable and terminal equipment being identified as in the cable schedules.
- Cable route and layout drawings. For those items which are underground, these drawings shall include the following:
- Route plans and sectional views for all cable runs, cable trays, cable ducts and cable trenches;
- The position of all marker posts, joints, draw pits and the like.
- Cable schedules shall detail the cable number, type, voltage, size, route length and number of cores or pairs. Control-cable schedules shall detail the connected and spare core numbers, diagram number for connected equipment, core ferrule and terminal reference number.

VIII. Data and calculations:

Manufacturers' catalogues and data sheets for all cables and fittings. Cable sizing Calculations.

IX. Test certificates:

Test certificates for all witnessed and routine tests carried out at the manufacturer's works and at Site (calibration).

X. Cable trays and ladders

Cable tray, covers, and cable-support ladders shall be of heavy-gauge galvanised steel and with an overall PVC coating when required to the approval of the Engineer.

Cable tray and ladder systems shall be installed with joints and junction/bend pieces. Wherever tray and ladder sections are cut and shaped on Site, cut edges shall be dressed and painted with at least two coats of cold galvanising compound or lead-based anti-corrosive paint.

Ladder systems shall be secured to walls and ceilings by pre-formed galvanized interlocking channel.

All instrumentation cables shall be laid in a separate cable tray with covers.

XI. Flexible conduits

Flexible conduit shall be of the waterproof galvanised type of PVC wire-wound type with cadmium-plated mild steel couplings. Lengths of flexible conduit shall be sufficient to permit withdrawal, adjustment or movement of the equipment to which it is attached and shall have a minimum length of 300mm. Flexible conduit shall not be used as a means of providing earth continuity. A single earth conductor of adequate size shall be installed external to the conduit complete with earth terminations.

Where a conversion from rigid conduit to flexible metallic conduit is required, the rigid conduit shall terminate in a trough-type box. The flexible conduit shall extend from this box to the equipment. The earth continuity cable shall be secured to both the box and the piece of equipment. The use of lid facing screws and the like will not be permitted. Adaptors shall incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.

XII. PVC conduit

Where galvanised conduit would be liable to corrosion, PVC conduit shall be installed.

PVC conduit shall be of the oval or round high-impact non-flame-propagating type as specified and self-extinguishing, to BS EN 61386-21. Surface and concealed installations shall be generally as described for steel conduit.
PVC conduit fittings shall comply with BS 4607. They shall all be white unless specified otherwise.

Jointing shall be carried out using PVC solvent and socketed accessories.

Expansion couplers shall be fitted in straight surface runs every 12m. The free end shall be sealed with non-setting mastic to form a waterproof seal.

Purpose-made bends may be used, provided that the cable bending radius is maintained. Cracked or crinkled conduit will be rejected.

The conduit shall be suitable for use in ambient temperatures ranging from −5°C to +60°C and shall not be installed in areas exposed to direct sunlight. A separate protective conductor (earth-continuity conductor) shall be installed.

Adaptable boxes and accessories shall be made from heat-resistant insulating material. The minimum wall thickness of boxes having a nominal internal depth of 16mm or less shall be 1.5mm. For deeper boxes, the minimum wall thickness shall be 2mm. All boxes which are intended to support luminaires or other heat sources shall have either external fixing lugs riveted to the metal inserts or utilize steel insert clips.

F. Cable installation methods

I. General

All cabling installation methods shall be subject to the approval of the Employer Representative.

II. Installation directly into the ground

Where cables are buried in the earth, the bottom of the excavated trenches shall be free of sharp stones and other projections and covered with sand to a depth of 50mm.

Cables shall be unrolled from drums without loops and kinks. Care shall be taken when laying them to avoid damage to the outer sheath by drawing over sharp projections.

Cables shall be snaked into the trenches to avoid tension in the cables during backfilling or from subsequent settlement. After laying, cables shall be covered to a minimum depth of 100 mm of compacted sand and shall have a layer of protective interlocking concrete cable tiles. The tiles shall be overlaid with marker tape.

When cables of different voltages are laid together at the same depth, vertical cable tiles shall be used to segregate the cables.

ICA and communication cables shall be laid at a distance of not less than 1000mm from high voltage cables.

A sufficient number of rollers shall be provided to prevent the cable from touching the ground or twisting during pulling.

III. Installation in underground ducts

Underground ducts shall be constructed of impact-resistant uPVC and laid at a minimum depth of 500mm (to the duct centre), surrounded by at least 75mm of sieved sand. At road crossings, uPVC ducts of a minimum diameter of 100mm shall be laid at a minimum depth of 1000mm (measured from the duct centre). The ducts shall be encased by 150mm concrete on all sides.

When installing cables in ducts, the following measures shall be observed:
- Cables shall be pulled in a straight line;
- Rollers shall be positioned at the edges of draw pits both at the drawing-in and drawing-out points over which the cables shall be drawn;
- PVC pipes and cable sheaths shall be coated with an approved lubricant;
- Sufficient draw-in points shall be provided and adequate room allowed for installation of cables;
- The pulling rope shall be guided by rollers.

Only one power cable shall be drawn into each duct.

Whenever a duct is laid in the ground, a draw wire shall be pulled through with at least 1000mm of excess at each end, and the draw wire left in position if the duct is not to be used immediately.

IV. Sealing cable entries into buildings

Whenever cables pass through walls below ground level, the point of entry shall be sealed against the ingress of water. This will be achieved using silicone foam or a similar material.

All cable entries into a building shall be in ducts, and where the cables pass in or out of ducts, together with any spare ducts, the ducts shall be sealed against the ingress of moisture by means of duct stoppers and bituminous compounds or by any other method approved by the Employer Representative. The stopper shall have a fire resistance of at least 30 minutes.

V. Marking of underground cables

The location of all underground cables shall be identified by:
- cast iron material plates with standard or custom design fixed to the exterior surface of all walls of buildings 300mm above ground level and directly above the point where cables pass through the wall;
- Marker posts in road verges and the like at intervals of not more than 100m and at all junctions and changes of direction along the route;
- Marker posts at 10m intervals within an enclosed site and at all junctions and changes of direction along the route.

Marker posts shall be of concrete, not less than 200mm high above ground, with inscribed cast iron material plates with standard or custom design. The inscription shall indicate the presence of a cable below, the depth, classification and voltage rating.

A drawing or sample of a typical marker post shall be submitted for the approval of the Employer Representative.

VI. Installation in cable trunking

Cable trunking shall be manufactured from mild steel of a thickness of not less than 1.25mm and shall be hot-dip galvanized. The Contractor shall ensure that the size of the trunking is adequate for the number of cables to be installed, along with a 25% spare capacity. Trunking shall have minimum dimensions of 50mm x 50mm.

Segregation of cables shall be carried out if required using continuous sheet steel barriers with the bottom edge welded to the trunking. The trunking shall have two return flanges for rigidity. Where necessary, additional strengthening straps shall be fitted internally. The cover shall overlap the trunking and be made of the same gauge. Fixing screws for covers shall be recessed and be of the self-retaining quick-fix type. All bends, tees, and intersections shall be of the gusset type and, wherever possible, shall be purpose-made by the manufacturer to match the design of the main trunking.
Cables shall be retained in the trunking when the cover is removed by means of straps. Internal connecting sleeves shall be fitted across joints in the trunking and earth continuity ensured by bonding each section of trunking to a continuous earth wire.

Non-flammable fire barriers shall be inserted where the trunking passes through walls or floors. Conduit connections to trunking shall be made by flanged couplings and male bushes.

Trunking shall be supported at intervals not greater than 2m horizontally or 2.5m vertically.

Crossings over expansion joints shall be made in flexible conduit.

Should it be necessary to cut or drill a section of trunking, the bare ends shall be immediately coated with zinc-rich cold galvanising paint.

Cable and trunking runs shall be determined by the Contractor and agreed by the Employer Representative before any work is started. The run shall be at least 150mm clear of plumbing and mechanical services.

Trunking systems erected outside a building shall be weatherproof.

VII. Installation in troughs and trenches

Where the building structure incorporates purpose-built covered trench systems, power distribution cables may be laid on the floor of the trench. Control and instrumentation cables shall be segregated and installed on supporting steelwork or cable trays secured to the walls of the trench.

Where the building structure incorporates general service trenches containing pipework, chemical lines and other services, all cabling shall be segregated from other services and run on the trench walls. Crossovers shall be kept to a minimum and cabling shall be taken above wet service pipework.

Cable trays shall be of perforated steel with formed flanges and of minimum thickness not less than 1mm for trays up to 100mm width, 1.25mm for trays from 100mm to 150mm width, and 1.5mm thickness for trays from 150mm to 300mm width.

Cable-tray supports shall be of sufficient strength to maintain rigid support for the fully laden cable tray along its entire length. All brackets and trays shall be suitable for withstanding a temporary weight of 125 kg.

Wherever possible, cable trays shall be installed in full lengths without cutting.

Should it be necessary to cut or drill a length of tray, the bare ends shall be dressed and immediately coated with zinc-rich cold galvanising paint. Similarly, for PVC-coated trays, the bare end shall be immediately sprayed using a PVC aerosol.

All cables shall be firmly secured to the tray using purpose-made saddles, as approved by the Employer Representative, together with proprietary cable cleats.

VIII. Installation in buildings

Cables required to be run on walls, ceilings, or other structures shall be supported on substantial cleats, either in groups or at spacings determined by rating requirements, and shall be carried on tray or ladder racks or enclosed in conduit or trunking.

All cables shall be neatly run vertically or parallel to adjacent walls, beams or other structural members.

The spacing of clips, saddles, and cleats shall be such that it prevents the sagging of cables during their installed life. The method of fixing clips and the like shall be through non-corrodible screws inserted into approved wall fixings.

Cable hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cables they are supporting. They shall be treated to withstand site conditions without corroding. Self-locking plastic buckle clips and strapping shall not be used.

Hangers shall be spaced according to recommendations in the IEE Wiring Regulations. Allowance shall be made for expansion and contraction of the cables.
Cables shall be located between 50mm pegs spaced at 40mm centres across a rung so that a 40mm or 80mm space is maintained between cable centres. Cleats shall be used where the ladder racking is vertical.

Cables shall be run at least 150mm clear of plumbing and below heating and hot water pipework.

IX. Cable installation in conduits

Conduits shall be either galvanised heavy-gauge steel screwed type or light-gauge steel non-screwed type, steel or PVC. Accessories shall either be malleable cast iron or pressed steel.

A space factor of 40% shall not be exceeded; in any case, the conduit shall have a minimum diameter of 20 mm. The tubing must be perfectly smooth inside and out, with no imperfections. Both ends of every length of tubing shall be reamed and all sharp edges removed before erection.

Where conduits converge, adaptor boxes shall be used. Conduits shall be connected through male brass bushes and couplings. Where conduits are greater than 25mm in diameter, straight-through joint boxes shall be of the trough type. Where conduit or fittings are attached to equipment casings, the material of the casing shall be tapped for a depth of not less than 10mm or male bushes and flanged couplings may be used.

Hexagonal lock nuts shall be used at running joints. They shall seat firmly and evenly onto mating faces. All function boxes, draw-in boxes, and inspection fittings shall be placed so that the cables can be inspected, withdrawn, and re-wired during the life of the installation.

Generally, no more than two bends, offsets, or one coupling will be permitted without a suitable inspection accessory. Fish wires shall not be left in conduits during erection. The whole of the installation shall be arranged for a loop-in type of system with joints being carried out at switches, isolators or appliance fittings. Ends of conduits which are liable to be left open for any length of time during building operations shall be plugged to prevent the ingress of dirt and covers shall be fitted on all boxes.

Generally, conduits shall not cross expansion joints of buildings. Where they cannot be installed in any other manner, a galvanised flexible conduit shall be used across the expansion joint. A total of 150mm movement shall be allowed.

7.11 Process Instrumentation

7.11.1 General

- The instrumentation system shall be designed, manufactured, installed, and tested to ensure high standards of operational reliability. All electronic components shall be adequately rated, and circuits shall be designed so that changes in component characteristics do not affect plant operation.

- All instrumentation equipment shall be new, of proven design, reputed make, and shall be suitable for continuous operation. Unless otherwise specified, all instruments shall be tropicalized. The outdoor equipment shall be designed to withstand tropical rain. Wherever necessary, space heaters, dust and water proof cabinets shall be provided. Instruments offered shall be complete with all the necessary mounting accessories.

- All instruments shall be from the country of origin as indicated in the vendor list elsewhere in this specification.

- All instruments, inclusive of the field instrumentation,(Flow meters, pressure gauges, transmitters, level instrumentation, temperature instrumentation, analytical instrumentation analyzers (DO, ORP, Chlorine, Multi parameters, Auto samplers, etc) shall be offered for inspection & testing before dispatch, at the manufacturers factory works where the instrument has been manufactured. The same shall be indicated in the QAP and submitted along with the equipment datasheet for review and approval.

- Electronic instruments shall utilise solid state electronic components, integrated circuits, microprocessors, etc., and shall be of proven design.

- No custom-made hybrid-type integrated circuits shall be used.

- Unless otherwise stated, overall accuracy of all measurement systems shall be ±0.5 % of the measured value, and repeatability shall be ±0.5%.

- Unless otherwise specified, the normal working range of all indicating instruments shall be between 30% and 80% of the full scale range.

- On resumption of the supply following a power failure, the instruments and associated equipment shall start working automatically.

- The instruments shall be designed to permit maximum interchangeability of parts and ease of access during inspection and maintenance.

- Unless otherwise stated, field-mounted electrical and electronic instruments shall be weatherproof to IP-65.

- All outdoor instruments shall be fitted with an IP65 enclosure to shield them against the weather, irrespective of the instrument's or transmitter's IP rating. The enclosures shall be of a lockable type.
- The instruments shall be designed to operate under ambient conditions of temperature, humidity, and chlorine contamination that may prevail, but in any case, not less stringent than those conditions detailed in the Project Requirements. Instruments shall be resistant to corrosion in the atmosphere in which they are expected to operate.

- All field instruments and cabinets/panel-mounted instruments shall have tag plates/name plates permanently attached to them. Details of proposed inscriptions shall be submitted to the Employer for approval before any labels are manufactured.

- All coated parts of sensors shall be made from a non-corrosive material capable of withstanding a chlorine content of 5 ppm.

- For all instruments installed in the field, surge protection devices (SPD s) shall be provided at both ends of the connecting cable for protection against static discharges / lightning and electromagnetic interference.

- Individual pair screened, overall screened, armoured cables shall be used for analogue signals and armoured, overall screened cable shall be used for digital signal cables.

7.11.2 Flow Measuring Systems

Flow measuring system shall consist of flow sensor / transducers, flow computer and flow transmitter.

Flow transducers shall be rugged in construction and shall be suitable for continuous operation. Flow transducers shall be of waterproof construction suitable for installation in underground/or above-ground pipelines.
To avoid the effects of disturbances in the velocity profile, a straight and uninterrupted run, upstream as well as downstream from the location of the flow sensor, shall be provided in accordance with the requirements of the flowmeter manufacturer.

The flow transmitter shall be suitable for field or panel mounting and shall accept an input from the flow sensor. It shall process the input signal and provide a 4-20 mA DC output proportional to the flow rate. The flow range shall be adjustable.

A zero span adjustment facility shall be provided for flow transmitter and indicator.

Flow measurement shall not be affected by physical properties of sewage viz., temperature, pressure, viscosity, density etc., within given limits. The Contractor shall provide compensating electronic circuits if required. The overall accuracy of flow measuring systems shall be at least ± 0.5 % of the measured value unless otherwise stated.

7.11.3 Open Channel Flow Meter

Open channel flow measuring systems shall consist of a level transducer, a flow computer, and a flow transmitter. The Radar level transducer shall measure the level of the fluid in the flume. The measured level shall be used in conjunction with the physical characteristics of the flume to calculate the flow rate.

The level transducer shall be suitable for flange or bracket mounting, as required, and shall be environmentally protected to IP67 standards. It shall have ambient temperature compensation and adjustable datum setting facilities.

The design and application of Radar level meters shall take into account the channel construction, the material size, shape, environment, process fluid or material, the presence of foam, granules, size etc.

The installation shall avoid any degradation of performance from spurious reflections, absorption, sound velocity variations, sensor detection area, temperature fluctuations, specific gravity changes and condensation. For applications where spurious reflections are unavoidable, the control unit shall be equipped with facilities for rejecting spurious reflections.

The structure required for supporting the level sensor, access platform, railings etc. shall be in the Contractor's scope.

7.11.4 Electromagnetic Flow Meter (Full Bore):

The Electromagnetic Flow Meters shall be installed in RCC chambers for indication of flow rate and totalized reading in the transmission or distribution pipe work of the system. The Electromagnetic Flow Meters shall withstand a maximum working temperature and working pressure as per the process requirement.

Full-bore electromagnetic flow meters shall be designed, manufactured, and calibrated to the ISO standard. The flow meter shall be capable of measuring bi-directional flow.

Electromagnetic Flow Meter shall be a velocity sensing electromagnetic type, microprocessor-based signal converter, Flow Integrator, and Totalizer sealed housing, flanged tube meter as per working pressure requirement. The meter shall be manufactured to the highest standard available for mag-meters. The accuracy shall be inclusive of linearity, hysteresis, and repeatability, temperature and pressure effects. The meter assembly shall operate within a range of 0.3 m/sec to 5 m/sec and the pressure rating shall be as per process requirement to be constructed as follows:

Meter tube shall have a constant nominal inside diameter offering no obstruction to the flow.

Signal Converter shall be pulsed DC coil excitation type with auto zeroing. The signal converter shall be remotely mounted away from the meter. The converter shall indicate direction of flow and provide a flow rate indication and a total of flow volume for both forward and reverse directions.

The converter shall provide an isolated 4-20 mA output. The microprocessor-based signal converter shall have a self-diagnostic test mode and a backlit display that continuously displays 'Rate of Flow' and 'Total Volume'.

The converter shall be compatible with Microsoft Windows and other software programs with built-in terminal communication capabilities of RS-485, HART, or other protocols for interface.

The converter shall be remotely mounted up to 200 m from the sensor, and shall be supplied with all calibration complete for the desired requirements.

The converter cum transmitter shall be fully programmable from the front facia.

The programming shall be user-friendly, self-prompting, and menu-driven.
The length of the sensor shall be strictly as per ISO up to DN 600 mm and for other sizes it shall be as per the manufacturer's standard.

All flow meters (applicable for all sizes of meters) shall be offered for inspection & testing before dispatch at the manufacturer's Factory where the instrument has been manufactured. QAP shall be submitted, which shall include functional testing and wet calibration (five-point) as well as hydrostatic pressure test at the manufacturer's factory.

I. Level Measuring System

a) Radar Type Level Transmitters

Supply, Installation, Testing & Commissioning of Non-Contact Radar Type Level Transmitter with 2-wired 4-20mA Analog Output, which has a minimum frequency of 24GHz (or as per medium requirement). The Principle of Operation is Frequency Modulated Continuous Wave (FMCW). The transducer shall be suitable for flange or bracket mounting as required and shall be environmentally protected to IP 67. It shall have ambient temperature compensation, adjustable datum setting facilities.

The accuracy of the sensor shall be ±3mm or better.

It shall be programmable with an integral programming keyboard and display the measured variable digitally. It shall be equipped with diagnostic facilities and provide an isolated 4 to 20 mA DC output signal proportional to the measurement range.

The design and application of Radar type level transmitters shall take into account the vessel or channel construction, the material, size, shape, environment, process fluid or material, the presence of foam, granules, size etc.

All instruments shall be offered for inspection and testing before dispatch at the manufacturer's Factory, where the instrument was manufactured. QAP shall be submitted, which shall include functional testing and calibration at the manufacturer's factory.

b) Conductivity Level Switches

The electrodes used for conductivity level switches shall be stainless steel. Single-electrode systems (one electrode per holder) shall be used, except where their use is impractical, with insulated electrodes such that only the tip of each electrode is exposed to the liquid at the operating level.

Relay or control units operating with level electrodes shall have adjustable sensitivity. Electrodes for use in fluids of low or variable conductivity shall be fitted with conductivity discs.

Where relay or control units are not mounted in control panels, they shall be provided with surface-mounting enclosures offering a degree of protection equivalent to IP 52 for indoor locations or IP 65 for outdoor locations.

All instruments shall be offered for inspection & testing before dispatch at the manufacturer's Factory where the instrument has been manufactured. QAP shall be submitted, which shall include functional testing and calibration at the manufacturer's factory.

II. Pressure gauges, Switches and transmitters

Pressure gauges shall comply with BS EN 837- Parts 1, 2 and 3. Pressure gauges, transmitters and switches shall have over range protection up to 1.5 times the maximum anticipated line pressure and have concentric scales. For specially arduous duty where the gauge is subject to pressure pulsations and/or vibration, it shall be provided with a glycerine-filled dial and line snubbers shall be used. Bourdon-tube type differential-pressure gauges shall be capable of withstanding full line pressure on any side with the other side vented to the atmosphere without damage to or effect on the calibration. No plastic material shall be used in their construction. Internal parts shall be of stainless steel, bronze or approved corrosion-resistant material.

The minimum diameter for round pressure gauges shall be 100mm unless specified otherwise or where the gauge forms part of a standard item of equipment.

Unless specified elsewhere, the accuracy for pressure gauges shall be 1% of range, for diaphragm gauges 1% of range, and for differential gauges 1.5% of range or better.

Where compensation of more than 2% of the instrument span is needed for the difference in level between the instrument and the tapping point, the reading shall be suitably adjusted and the amount of compensation shall be marked on the dial.

The zero and span of a pressure transmitter shall not change by more than 0.1% of the span per Celsius degree change in ambient temperature. After application for 10 minutes of pressure at 130% of maximum pressure, the change in zero and span shall not exceed 0.1% of the span.

Pressure transmitters/switches shall have an accuracy typically better than 0.1% of span, depending on the application and shall be protected to BS EN 60529: IP 65 standard or higher standard. For transmitters installed in meter chambers liable to flooding or underwater applications, they shall be to BS EN 60529: IP 68 standard and shall operate up to a maximum submergence of 20 metres of water.

Pressure transmitters shall provide a digital or 4-20mA DC output proportional to the pressure range.

Pressure gauges, switches, and transmitters shall have primary isolating valves, a 2 or 3-way valve manifold, and vents, in such a way that it has the facility to calibrate the gauges or transmitters without removal.

Pressure and differential pressure switches shall have contacts with separate ‘cut in’ and ‘cut out’ pressure values.

The nominal pressure values at which pressure switches operate shall be fully adjustable over the whole range of the instrument, and the set value(s) shall be clearly indicated by means of a scale and pointer.

Pressure monitoring shall be by a sensor suitable for the medium and pressure/level range.

The sensor shall be suitable for either free wire suspension in the medium or fitted remotely and provided with threaded sockets to permit connection of pressure pipework.

A transmitter shall be provided either integral with the transducer or separately mounted and converting the signals received from the transducer to a 4 to 20 mA signal proportional to the range specified.

The transmitter shall have provision for span and zero adjustment.

III. Strain-gauge pressure transducers and transmitters

Strain-gauge pressure transducers shall utilize thin-film sensors without bonding.

Each instrument housing shall be of all-welded Grade X 4 CrNiMo 17 12 2 stainless steel or equivalent and hermetically sealed. Non-interacting, zero and span adjustments shall be provided on each transducer. The measuring diaphragm shall be isolated from the process fluid by a non-corrodible barrier diaphragm. The mean time between failure for any model of strain-gauge transducer shall be not less than 15 years, and the performance of the measurement system shall be as given below, or higher performance:

- accuracy: ± 0.1% of calibrated span, including linearity hysteresis and repeatability;
- repeatability: ± 0.05% at maximum span;
- stability: ± 0.1% of upper range limit over 6−month period;
- over pressure: sustain a 400% over-pressure without damage;
- RFI / EMI effect: less than 1% of span with 500MHz at 5W direct contact;
- power supply variation effect: 0.01% per volt variation.
- load variation effect: ±0.0002% per ohm of loop-resistance variation.
- temperature: −29°C to +82°C range; total thermal error of ±0.75% of span over 0°C to 50°C;
- protection: IP 65.

Strain-gauge transducers that do not have terminals for their cable connection shall have integral sealed-cable assemblies installed in conduit and terminated at weatherproof junction boxes, protected to IP 65, each mounted near its associated process transmitter. A digital or 4mA to 20mA DC output signal proportional to the transducer range shall be provided.

Strain-gauge pressure transmitters shall be generally as the transducer except that it shall incorporate a waterproof pressure transmitter producing a digital or 4mA to 20mA output signal.

Provision for venting the transducer shall be made.

All instruments shall be offered for inspection & testing before dispatch at the manufacturer's Factory where the instrument has been manufactured. QAP shall be submitted, which shall include functional testing and calibration at the manufacturer's factory.

IV. Temperature Instrumentation

- Resistance Thermometers

Platinum resistance thermometers shall be used for temperature sensing up to 650 Degree C.

Each temperature sensor, used for process monitoring, shall have a stainless steel pocket and extension assembly, a non-corrodible metal sheath, and a waterproof terminal head. Pockets for steam, oil and pressurised water lines shall be welded; pockets for other duties shall be screwed. Temperature sensors incorporated within motor winding shall be inserted during the winding process to ensure intimate contact.

Platinum resistance thermometers shall be selected and used as per BS 1041-3 and shall comply with BS EN 60751. Each element shall be artificially aged during the manufacturing process. Terminal heads and amplifiers shall be designed for three-wire connections between head and amplifier.

Platinum resistance elements shall be fully encapsulated in ceramic, and the element and high-temperature-resistant lead wires shall be hermetically sealed. The associated resistance-to-current converters shall have zero and span adjustments, as well as input-output circuit isolation.

- Thermocouples

Thermocouples shall be of the mineral-insulated type and, unless otherwise specified, shall be of the chromel-alumel (nickel-chromium-vs-nickel-aluminium) type. Wires shall not be smaller than 1.0 mm2 and shall be selected and used in accordance with BS 1041-3 and shall comply with BS EN 60584.

Note: All instruments shall be offered for inspection & testing before dispatch at Manufacturers Factory where the instrument has been manufactured. QAP shall be submitted which shall include functional testing and calibration at the manufacturer factory.

V. Analytical Instrumentation

In all cases, the location and housing of the monitor shall take into account the provision of a representative sample to the monitor sensor, the pre-conditioning if any, required prior to the sample's analysis, operator requirements for access, maintenance, calibration, repair and replacement of the monitor or its sensors.

This section covers individual elements to measure and transmit pH and ORP. Transmitters shall convert the sensor measurement to a 4 to 20 mA DC signal capable of transmission into at least a 500 ohm load at 50 V or less. Power supply shall be 240 Vac, 50 Hz. Reference accuracy of the output signal shall be ± 1 percent of measured span or better. Output signal shall be electronically isolated from ground to permit connection to a receiver with a grounded input. Transmitters shall be provided with an indicating scale having at least a 0.1-meter calibrated length. Operating ambient temperature shall be -5 to + 50 degree C or better. Transmitted signals shall be linear with the measured variable, excepting pH, which shall be linear with pH.

- **Sensor Measurement Principles and Features**:

Each type of sensor shall use the measuring principle and incorporate the features appropriate to it as specified below:

pH and ORP sensors shall measure hydrogen ion activity and oxidation-reduction potential, respectively, in the process medium. The pH sensor shall consist of a glass measuring electrode, a reference electrode, a solution ground and a temperature sensor for compensation in the transmitter. The reference electrode shall be of the non-flowing type, utilizing an electrolyte diffusion rate through a non-reactive, porous membrane or plug, which shall not require electrolyte refill more frequently than once per year. ORP sensors shall use the same elements specified for pH sensors, except that the electrode shall be platinum, and no temperature compensation is required. pH and ORP sensor assemblies shall incorporate an integrally mounted preamplifier for the measuring electrode. Sensors shall operate over a temperature range of - 5 to + 1000 C or better.

Construction. Transmitter and sensor enclosures shall be rated NEMA 4 unless explosion proof (XP) is specified on the Schedule. Enclosure materials and finish shall be as specified in the Schedule. If not so

specified, they may be the manufacturer's standard, which is compatible with the corrosivity of the atmosphere normally in contact with the enclosure. All parts of sensors, their assemblies and supporting parts which are wetted by the process medium shall be constructed of stainless steel and/or plastic unless specified otherwise on the Schedule. When specified on the Schedule, pH and ORP assemblies shall be provided with integrally mounted ultrasonic cleaners.

Total Dissolved Oxygen Monitoring System

The Dissolved Oxygen (D.O) monitoring system shall consist of a sensor, transmitter, indicating converter and electrode cleaning equipment. Accuracy shall be $\pm$ 0.5% full scale for DO, barometric pressure $\pm$ 0.27 kPa and temperature $\pm$ 0.3°C.

The sensor shall not require zero point. The transmitter shall allow the DO sensor to be fitted without the use of tools. The transmitter shall output a signal proportional to the DO level and measured temperature. The following alarms shall be detected and transmitted.

1) Membrane puncture
2) Depleted or worn out DO sensor
3) System/electronic fault.

The indicating converter shall perform auto calibration of the system and compensate for sensor age, temperature, barometric pressure, relative humidity, and liquid salinity. It shall display OD concentration, temperature, sensor lifetime remaining (mg/l x hours or %) and rh selected for calibration.

Construction: The DO sensor shall consist of a prefabricated, disposable, sealed cartridge that slides easily into the transmitter without the need for special tools. Systems that require regeneration (refill of electrolyte and membrane change) shall not be acceptable. The sensor shall use the Clark's principle, with a gold cathode, silver wire anode and a nontoxic electrolyte of potassium chloride. The pre-stressed membrane shall be of Teflon and bonded onto the DO sensor.

The transmitter shall be protected to IP 67 and supplied with a minimum of 15 m of cable for connection to a junction box. The converter shall be housed in a NEMA 4 x enclosure and be handrail or panel mounted up to 200m from the sensor without need for a pre-amplifier. It shall be interchangeable without the need for recalibration or reprogramming of the system by using a sensor-specific storing device, continuing all settings and calibration.

The sensor and transmitter shall be installed in a self- cleaning polystyrene ball float, which shall float on the surface of the water and allow the sensor to be inserted by approximately 125mm into the water. The ball shall be constructed to fit the sensor and transmitter and leave a smooth surface to prevent accumulation of dirt or grease.

Note:" All instruments shall be offered for inspection & testing before dispatch at the manufacturer's Factory where the instrument has been manufactured. QAP shall be submitted, which shall include functional testing and calibration at the manufacturer's factory.

7.12 Installation Requirements for Instruments

7.12.1 General

The Contractor is responsible for coordinating the installation, testing, and commissioning to ensure proper interface and system integration. Services shall include, but not necessarily be limited to, all labour,

materials, tools, equipment, supplies, and services, and auxiliary devices, including brackets and mounting hardware, required to install the instrumentation.

7.12.2 The following general installation guidelines shall apply:

- Transmitters and transducers shall be mounted as near as practical to the measurement point. The transmitter shall be installed at a suitable location and height for the operator to view the transmitter display
- Instruments shall be readily and safely accessible from grade, permanent platforms or fixed ladders to facilitate ease of maintenance for the equipment.
- Supply power to instrumentation from the control panel to which information is reported for remote monitoring. Provide a separate (independent) circuit for each analyzer (note that control panels are powered by online UPS and supplied from the sites critical emergency power circuit).
- Unless otherwise shown or specified, all instruments shall be mounted 1.4 m above finished floors, grade or platforms. Allow for cabinet plinth/floor-pad heights when locating panel instruments.
- Do not mount direct-reading or electrical transmitters directly on process piping. Mount the instrument on instrument racks or stands, or in enclosures near the sensor, at a level that permits viewing from ground elevation.
- Do not mount instruments on vibrating structures (e.g. handrails), or on piping or near equipment that may induce vibration.
- Do not mount instruments below or directly adjacent to lines conveying corrosive chemicals or near sources of leakage or spillage.
- Install the instrumentation and auxiliary devices (including sensors) such that they are accessible for maintenance. Provide space between instruments and other equipment and piping for ease of removal and servicing. Install to ensure accessibility from grade without requiring staff to enter confined spaces.
- Ensure that instrument displays are properly oriented for easy viewing.
- Any instrument that is not easily accessible for operation or maintenance, and any indicator that is not easily and readily visible, must be relocated as directed at no charge to the contract.
- Follow additional installation requirements as specified in the individual instrument sections and as recommended by the manufacturer.
- Follow the Manufacturer’s recommendations for loading resistors on digital outputs to limit the affect of leakage currents through triac and relay outputs.
- Follow the Manufacturer’s recommendations for surge suppression on inductive loads.
- Unless specifically instructed otherwise, ensure installations conform to the manufacturer's installation recommendations.

7.12.3 Analytical Instrumentation

- Physically locate the sample point so as not to contribute unnecessary dead time in the analysis. Take care to ensure the sample point is clean, thoroughly mixed, and representative of the process stream.
- Locate the analyzer next to a floor drain. Provide shutoff (block) and bleed valves: specify the size, type, and material for the application.

- Provide flushing facilities for cleaning probes

7.12.4 Surge Protection Devices

Surge protection devices (SPDs) shall be suitable for withstanding the surge arising out of high energy static discharge / lightning strikes and protect the instrument to which it is connected against damage. SPDs shall provide protection through the use of quick-acting semiconductors like Tranzorb, Zener diodes, varistors, and an automatic disconnect and reset circuit. SPDs shall be passive and shall require negligible power for

operation. During the occurrence of a surge it shall clamp on the allowable voltage and pass the excess voltage to the ground. The SPD shall be self-resetting to minimise the downtime of the measurement loop.

SPD s shall be provided to protect devices transmitting and receiving analogue and digital signals derived from field devices located outdoors.

The surge protection device shall be rated for a surge rating of 10 KA.

7.13 Control & Automation

7.13.1 Programmable Logic Controllers

WwTP in this contract shall be provided with a PLC-based SCADA system. Programmable Logic Controllers (PLC) shall be provided as a Hot Stand-by Controller to perform combinational and sequential logic functions, status monitoring, process control, and reporting functions with counter and timer facilities. In particular, there shall be a single vendor for WwTP and ISPS under this contract to ensure uniformity among equipment and spare holding.

In particular, the following configuration shall be applicable across the WwTP.

The plant PLC system shall be a hot standby PLC linked to the plant's redundant SCADA system. The process systems shall be equipped with individual RIO panels featuring a 15" color HMI with touchscreen functionality, and RIO modules that communicate with the main plant PLC for monitoring and control. No separate PLC system for monitoring and control of process system or complete plant control from process system vendor shall be accepted. Contractor shall note the importance of this clause.

PLC shall comprise the necessary processors, Simplex input/output (I/O) modules, communication interface modules, and Human-Machine Interface (HMI) required to perform the desired functions.

PLC shall have the following attributes as a Hot Stand-by Controller.

- carry out sequential logic implementation for operations of plant;
- carry out computation and interfacing for data acquisition, data storage and retrieval;
- it shall accept downloaded program from a programmer;
- it shall have different functional modules to perform the desired functions;
- it shall scan the inputs in time cycles and update the status of its outputs;

The PLC system shall be expandable, OPC Compatible and shall be modular in construction, so as to be capable of future expansion without hardware modifications. PLCs shall be microprocessor-based. PLCs shall use standard known protocols and structures for communication outside the system.

In case of system failure or power supply failure the outputs shall attain a predetermined fail safe condition (this shall normally be 'off').

The PLC used shall have a proven record in the type of application concerned and in the prevailing environmental conditions.

PLC System & all RIO systems should be housed in air conditioned environment.

The Contractor shall submit the sizing calculations for the air conditioning system for review and approval. The Contractor shall refer the approved vendor list for the PLC system and hardware, elsewhere in this document.

7.13.1.1 Remote input/output modules (RIO)

The PLC system shall consist of field remote input/output modules (RIO) panels. Each RIO panel shall consist of redundant communication modules, power supply modules, and a minimum 15" color panel-mounted HMI with touch screen functionality. It shall be possible to view and acknowledge the alarms and view set points for the particular process from the HMI etc. The HMI shall be configured such that the plant operator can view and control the previous and next process sequence from the HMI along with the set points. and alarms.

7.13.1.2 I/O Modules:

Standard rack-mounted plug-in I/O modules shall be provided. I/O Modules should be of the same series as the PLC CPU. Refer the approved vendor list (Part-13) for the PLC system and hardware, elsewhere in this document.

Field wiring shall be terminated in screwed terminal blocks and interconnected to the processor I/O system with prefabricated cables and plug in card type connectors. I/O Modules should be hot swappable. Provision shall be provided for future expansion of additional 30% extra I/O modules of the installed capacity in the panel.

I/O modules shall be as follows:

a) Inputs shall be opto isolated;
b) filters shall be provided for noise rejection;
c) output status shall be indicated by an LED;
d) all outputs shall be fuse protected and have fuse failure indication the fuses may be mounted externally from the output module;
e) All the modules shall be of addressable type.
f) Ethernet I/O modules shall be connected to the PLC by an onboard Ethernet 10/100 Base T connection port. Ethernet I/O modules shall support multiple communication protocols, including TCP/IP, Modbus ASCII, and Modbus RTU, allowing connections to any device supporting these protocols over a standard Ethernet backplane.

7.13.2 Ethernet Switches

The Contractor shall only provide managed industrial-grade Ethernet switches under this contract. A minimum 16-port managed Ethernet switch shall be provided.

7.13.3 PLC Programming

The Contractor shall supply, install, program, and commission the PLC using the PLC manufacturer's recommended Windows-based PLC coding and documentation software. The PLC code shall be structured in accordance with the best industry standard and have comprehensive subroutines and rung annotations.

PLC programming under this contract shall be implemented using only functional block diagrams (FBD).

The logic shall be prepared using proprietary programming software and shall be comprehensively annotated with subroutine and rung comments to assist further development and maintenance.

The system shall support a simple programming of the application software comply with IEC 61131-3.

The system shall support a structured, modular programming. At least the following standard operations shall be applicable:

1) Logic functions (such as AND/OR/AND NOT etc.);
2) Timer functions (externally adjustable);
3) Counter functions;
4) Skip functions;
5) Comparison functions;
6) Limit value functions;
7) Arithmetic functions;
8) Physical unit functions;
9) Closed-loop functions such as P/PI/PID/etc.

The Contractor shall submit the logic diagrams for review & approval as an integral part of FDS submissions.

The Contractor shall provide all required IT Hardware complete with PLC coding and documentation software as specified in the bid document & as agreed with the Employer representative based on the FDS submitted.

7.13.4 Supervisory Control & Data Acquisition System (SCADA) system

WwTP in this contract shall be provided with a dual redundant SCADA system and Historian software. The SCADA shall be suitable for day-to-day operation by non-computer-literate personnel in the monitoring and operation of the treatment works. In particular, there shall be a single vendor for WwTP and ISPS under this contract to ensure uniformity among SCADA and Historian softwares.

SCADA shall be provided at the central Monitoring Room, which shall be located in the administration building.

WwTP shall be provided with a Dual redundant SCADA system. The SCADA software shall be a minimum ten thousand tags version lifetime licensed without any time-bound. The SCADA System shall be designed to store, archive and retrieve complete plant operational data for at least six (6) months. This shall be provided in addition to the Historian software being provided at WwTP.

The Historian software shall be designed and configured to accept a minimum of thousand tags. The Historian software and server system shall be designed and configured to store data for a minimum of seven years.

At a minimum, the WwTP SCADA system shall generally consist of the following:
1) SCADA software's & licensing as indicated above.
2) SCADA redundant servers
3) Historian software & station as indicated above
4) SCADA Operator workstation with licensed SCADA software (inclusive of Latest Windows OS, Anti-Virus software, firewall, and required licensed software)
5) SCADA Engineering work station with licensed SCADA software (inclusive of Latest Windows OS, Anti-Virus software, firewall, required licensed software) and 32" LED monitors
6) A3 size all in one printers
7) Managed industrial grade Ethernet switches
8) 55" 2X3 LED screen which shall act as a mimic for the SCADA system along with required controllers and display system
9) Industrial grade control room console with minimum 5 nos of ergonomically designed seating systems for plant operators and supervisors.
10) File record shelves with glass doors with locking facility (at least two) to store SCADA alarms, records, operator notes, etc.,,,,

The SCADA system shall provide efficient and safe operation of the entire plant by detecting alarm and error conditions, alerting the operator to these conditions both visually and audibly, monitoring all important system parameters and providing facilities for plant optimization. The system will allow operators, technicians, and engineers to issue commands to change system parameters, start and stop equipment, provide configuration tools, and operate diagnostic facilities from Operator Workstations (OW) and Engineers Workstations (EW), after successful log-on by security password.

The System shall perform all the necessary functions for the optimum monitoring, automatic control and operation of the entire plant.

The SCADA control room shall be equipped with False flooring and a false ceiling. The entire control room shall be provided with air-conditioning systems (at least two 2-tonne split-type air conditioners in the main control room area & to provide one split-type air conditioner at each RIO Panel Room).

The SCADA control room shall be designed to provide a maximum view of the plant and its operation. The brick masonry works in the control room shall be replaced with full-length glazed windows. No UPS system shall be installed in the control room. A separate UPS room with a battery room shall be provided in the administration building for the purpose.

The SCADA system shall provide efficient and safe operation of the process plant by detecting alarm and error conditions, alerting the operator to these conditions both visually and audibly, monitoring all important system parameters and providing facilities for plant optimisation. The system will allow operators, technicians, and engineers to issue commands to change system parameters, start and stop equipment, provide configuration tools, and operate diagnostic facilities from Operator Workstations (OW) and Engineers Workstations (EW), after successful log-on by security password.
MIS-2
The System shall perform all the necessary functions for the optimum monitoring, automatic control and operation of the entire system. The SCADA control room shall be equipped with false flooring to provide access for all cables. No cables shall be installed over the control room floor.

Note: Refer to the particular specifications for the design of the SCADA control room and the particular requirements.

7.13.5 Uninterruptible Power Supply (UPS)

The power for entire control system inclusive of SCADA system,Programmable Logic Controllers (PLC) and RIO panels inclusive of all IT hardware, centrifuge PLC & complete field Instrumentation system, Fire alarm system and CCTV system shall be derived from separate redundant UPS system.

The UPS provided shall be sized to provide power to maintain system functioning for a period of minimum two hours (120 Minutes) on full load, in case of power failure.

The UPS shall be an online UPS, i.e. the status & complete operating parameters of the UPS shall be monitored by the plant SCADA system in real time.

The above feature should be demonstrated during UPS Factory Acceptance Test (FAT) & Site Acceptance Test (SAT).

List of Abbreviations

ADSL	:	Asymmetrical Digital Subscriber Line
ARP	:	Address Resolution Protocol
ASTM	:	American Society for Testing and Materials
BGP	:	Border Gateway Protocol
BOD	:	Biochemical Oxygen Demand
BWSSB	:	Bangalore Water Supply and Sewerage Board
CCTV	:	Closed Circuit Television
CDMA	:	Code Division Multiple Access
CPHEEO	:	Central Public Health & Environmental Engineering Organization
CPU	:	Central Processing Unit
CSMC	:	Centralized SCADA Monitoring Centre (i.e. MIS-2 at Shimsha Bhavan)
DDNS	:	Dynamic domain name system
DHCP	:	Dynamic Host Configuration Protocol
DN	:	Diameter nominal
DNP	:	Distributed Network Protocol
DNS	:	Domain Name System
DSL	:	Digital Subscriber Line
EN	:	European Norm or European Standard
ES	:	Engineering Station
FAT	:	Factory Acceptance Test
FDS	:	Functional Design Specification
FNU	:	Formazin Turbidity Units
GPRS	:	General Packet Radio System
GRE	:	Generic Routing Encapsulation
GSM	:	Global System for Mobile communication
HMI	:	Human Machine Interface
HTTP	:	Hypertext Transfer Protocol
ICMP	:	Internet Control Message Protocol
IEEE	:	Institute of Electrical and Electronics Engineers
IP	:	Ingress Protection
ISO	:	International Standards for Organization
ISP	:	Internet Service Provider
ISPS	:	Intermediate Sewage Pumping Station

kA	:	Kiloamperes
KPCB	:	Karnataka Pollution Control Board
LAN	:	Local Area Network
LED	:	Light Emitting Diode
LIMS	:	Laboratory Information management system
LPS	:	Lifting Pumping Station
MCCB	:	Molded Case Circuit Breaker
MIS	:	Management Information System
MLD	:	Millions Liter per Day
MPI	:	Message Passing Interface
NAT	:	Network Address Translation
NEMA	:	National Electrical Manufacturers Association
NGT	:	National Green Tribunal
NTP	:	Network Time Protocol
NTU	:	Nephelometric Turbidity Unit
O&M	:	Operation and Maintenance
OEM	:	Original Equipment Manufacturer
OPC	:	OLE for Process Control
ORP	:	Oxidation-Reduction Potential
OSI	:	Open Systems Interconnect
OSPF	:	Open Shortest Path First
OWS	:	Operator Workstation
PLC	:	Programmable Logic Controller
PPP	:	Point-to-Point Protocol
PPPoE	:	Point-to-Point Protocol over Ethernet
PVC	:	Polyvinyl Chloride
QAP	:	Quality Assurance Plan
RIO	:	Remote Input & Output
RIP	:	Routing Information Protocol
RS	:	Serial Communication (RS-232 / 485)
RTU	:	Remote Terminal Units
SAT	:	Site Acceptance Test
SCADA	:	Supervisory Control & Data Acquisition
SMTP	:	Simple Mail Transfer Protocol
SPD	:	Surge Protection Device
SS	:	Soft Switch
SSH2	:	Secure Shell protocols
SWA	:	Steel Wire Armoured
TCP/IP	:	Transmission Control Protocol/Internet Protocol
THD	:	Total harmonic distortion
TOC	:	Total Organic Carbon
UDP	:	User Datagram Protocol
UPS	:	Un-interruptible Power Supply
UV	:	Ultraviolet
VFD/VSD	:	Variable Frequency Drive/ Variable Speed Drive
VLAN	:	Virtual Local Area Network
VPN	:	Virtual Private Network
WEP	:	Wired Equivalent Privacy
Wi-Fi	:	Wireless Fidelity

WPA	:	Wi-Fi Protected Access
WwTP	:	Waste Water Treatment Plant
XLPE	:	Cross Linked Polyethylene

End of Part-7

PART 8

GENERAL MECHANICAL REQUIREMENTS

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PART 8

GENERAL MECHANICAL REQUIREMENTS

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PART 8

GENERAL MECHANICAL REQUIREMENTS

8.1 Wet Wells

(a) For the TSPS/ISPS, to prevent sewage from becoming septic, the maximum retention of sewage in the wet/suction well shall not exceed 30 minutes for the average flow in the Ultimate year.

(b) The depth of the sump shall be such that it provides at least a 15% margin over the minimum required pump submergence, calculated at the duty point on the basis of the Hydraulic Institute Standard.

(c) The wet well effective operating volume (volume between low level where all pumps are shut off and high level where all pumps except standby are operating) shall be such that the hydraulic retention time in this volume at peak flow in the ultimate year is not less than 5 minutes and the number of starts per hour does not exceed 6 for any single pump under any circumstances.

(d) Appropriate baffles shall be provided in the wet/suction well to prevent excessive turbulence and air entrainment when the material to be pumped falls freely.

(e) Benching shall be provided at the bottom of the wet well, near the suction bell mouth, to ensure that the pumps can completely drain the wet well.

(f) The wet well design shall incorporate corner fillets and ogees as appropriate to eliminate dead spots, prevent accumulation of solids or debris, and ensure the flow hydraulics ensures automatic self-cleaning of the wet well.

(g) The tops of the wet well wall, valve chamber walls, and electrical cubicle structures shall be a minimum of 750 mm above the finished ground level. No buried/ submerged structures shall be accepted for the wet well.

(h) Priming of pumps shall be ensured by providing a positive suction head.

(i) Operation of sewage pumps shall be automatic based on the sewage levels in the wet well.

(j) A standby unit of each type and size of pump employed shall be provided as specified in the mechanical requirements, and these shall be the minimum requirements.

(k) The clearance between the pump to pump outer periphery shall be not less than 1000 mm.

(l) The sequence of operation of raw sewage pumps shall be changed every 8 hours to avoid burn out of the pumps in the wet/suction well.

(m) + 5% margin on the pump capacity shall be provided for all the pumps.

(n) The total head of the pump shall be selected considering peak flow and maximum design level in the wet well for normal operating conditions and checked for satisfactory operation under extreme conditions of operation; the selected head to be revised if required.

(o) The minimum permissible velocity in the pumping mains shall be 0.6 m/sec. The maximum velocity in the pumping main shall not exceed 2 m/sec.

(p) All dry well pumping stations shall be provided with a pit and drain pumps with rigid DI piping (1 working + 1 standby) to automatically empty the stuffing box drain. All Wet well pumping stations shall be provided with a pit and drain pumps with PVC flexible piping (1 working + 1 standby) for complete draining during maintenance.

(q) Ventilation shall be provided for all the pumping stations based on 15 air changes per hour.

(r) For TSPS/ISPS, mechanical rake coarse/medium bar screen shall be provided upstream of the pumping station wet well. Provisions shall be made to allow lifting of screenings by screw conveyor.

(s) Appropriate lifting devices shall be provided for safe and easy retrieval and/or removal of the pumps from the wet well or dry well for maintenance or any other purpose at all pumping stations.

(t) On the Common header of TSPS, ISPS, Primary Sludge, RAS, Thickened Sludge, Centrifuge feed, Digester sludge and all pumping system shall be provided with a Motorized Knife Gate Valve on upstream of Flowmeter and a Swing Check Valve on downstream side.

8.2 Vertical Dry Pit Pumps

8.2.1 General

The total head capacity curve shall be continuously rising towards shut off, with the highest at shut off.

(a) Pumps shall be suitable for single as well as parallel efficient operation at any point in between the maximum and minimum system resistances.

(b) Pumps shall run smoothly without undue noise & vibration. Noise level shall be limited to 85 dBA at 1.86 M at sites. Vibration shall be limited to class II C of BS 4675/ zones A & B of ISO 10816. The pump set shall be suitable for starting with discharge valve open or closed. Abnormal sound and noise from the pump set and/or motor will not be acceptable.

(c) The pump set shall be capable of withstanding accidental rotation in the reverse direction.

8.2.2 Features of Construction

(a) Pump shall be centrifugal, back pullout, single stage type.

(b) Pump casing shall be of robust construction. Liquid passages shall be finished smooth and designed to allow free passage of solids. The volute tongue shall be straight across and filed to a smooth rounded edge. Casing shall be provided with wearing ring.

(c) Hand hole shall be provided in the casing to allow easy access to the impeller as well as to the casing throat. Casing drain connection with stainless steel collared plug shall be provided.

(d) Impeller shall be non-clog, enclosed type with smooth blunt edges and large waterways to allow free passage of the 50 mm size solids. It shall be free from sharp corners and projections likely to catch and hold rags and stringy material.

(e) The critical speed of the rotor shall be at least 30% above the operating speed. Complete rotor shall be balanced dynamically as per ISO 9906. The pump shut-off head shall be minimum 110% and maximum 130% of the rated pump head.

(f) Replaceable shaft sleeves shall be provided and shall be securely locked or keyed to the shaft to prevent loosening. The surface hardness of the shaft sleeve shall be a minimum 400 BHN.

(g) Bearings shall be easily accessible for inspection and maintenance. The bearings shall have a minimum working life of 100,000 hours. Bearings shall be grease lubricated or non-grease type.

(h) Glands shall be fitted with suitable mechanical seals. The gland arrangement shall be designed for ease of adjustment or removal of the seal. Stuffing boxes drain with pipe connection shall be provided at the lowest point so that no leakage accumulates in it.

(i) Mechanical seals shall be provided. Grease shall be used for stuffing box sealing. Water will not be available for this purpose.

(j) The pump and motor shall be coupled through a flexible coupling. The motor shall be mounted directly on pump casing.

(k) Tapping's shall be provided at suction and discharge nozzles for pressure gauge connection. Water flushing arrangement shall be provided for cleaning of sludge pipeline at its delivery side.

(l) Impeller wear ring hardness shall be min 50 BHN higher than that of Casing wear ring.

(m) The material of construction for Centrifugal Dry Pit Pump shall be as follows:

Sr. No.	**Component**	**Material**	
		Non-clog type	**For clean water (for service water etc.)**
(i)	Impeller *	Stainless Steel: ASTM A	Stainless Steel: ASTM A

Sr. No.	Component	Material	
		Non-clog type	**For clean water (for service water etc.)**
		743 CF8M	743 CF8M
(ii)	Casing *	Cast Iron to BS EN: 1561 Gr EN-GJL-200	Cast Iron to BS EN: 1561 Gr EN-GJL-200
(iii)	Shaft*	Stainless Steel: BS:970 Gr 431 S29/ASTM A 276 Gr.431	Stainless Steel: BS:970 Gr 431 S29/ASTM A 276 Gr.431
(iv)	Shaft sleeve*	Stainless Steel: ASTM A 743 CA 15 Hardness 400 BHN	Stainless Steel: ASTM A 743 CA 15 Hardness 400 BHN
(v)	Casing ring*	Stainless Steel: ASTM A 743 CA 15	Stainless Steel: ASTM A 743 CA 15
(vi)	Impeller ring*	Stainless Steel: ASTM A 743 CA 15	Stainless Steel: ASTM A 743 CA 15
(vii)	Mechanical seal (Motor side and Pump side) *	oil-lubricated with tungsten carbide or silicon-carbide faces	oil-lubricated with tungsten carbide or silicon-carbide faces

* Material test certificates shall be furnished by the Contractor.

8.3 Submersible Pumps

8.3.1 General

Pumps and drives shall be rated for continuous duty and shall be capable of pumping the flow range specified in the specifications without surging, cavitations or excessive vibration to the limits specified. The pump shall meet maximum allowable shut-off head. The pumps shall not overload the motors at any point on the maximum pump speed performance characteristic curve and the pump operating range within the limits of stable pump operation. The total head capacity curve shall be continuously rising towards the shut-off as flow decreases throughout the entire curve from run out to shut-off head with the highest at shut off. Its total head capacity curve shall be continuously rising towards shut off with the highest at shut off, and its capacity shall be meet to handle sludge volume.

(a) Pumps shall be suitable for single as well as parallel efficient operation at any point in between the maximum and minimum system resistances.

(c) The pumps shall be designed to handle solid sizes of up to 100 mm for the raw sewage application and 50 mm for all other process fluids. Specific gravity of sewage is 1.02 and Sludge 1.05.

(d) Pumps and motors shall run smooth without undue noise and vibration, cavitations, oil or water leaks over the range of operation. To ensure vibration free operation, all rotative components of pump shall be statically and dynamically balanced to BS 6861 as per zones A&B of ISO 10816-1.

Vibration levels shall not exceed the levels given in BS 4675. Abnormal sound and noise from the pump set and or motor will not be acceptable.

(f) The pump set shall be suitable for starting with the discharge valve open and/or closed.

(g) The pump set shall be capable of withstanding the accidental rotation in the reverse direction.

8.3.2 Features of Construction

(a) The pump shall be a centrifugal, vertical spindle, non-clog, wear-resistant, and single-stage type.

(b) Pump casing shall be of robust construction. Liquid passages shall be finished smooth and designed to allow free passage of solids. The volute tongue shall be filed to a smooth, rounded edge.

(c) Double Mechanical seals (back-to-back) shall be provided to protect the motor from ingress of sewage along the shaft. The preliminary and secondary seals shall be oil-lubricated with tungsten carbide or silicon carbide faces, and they shall be equipped with an electrical monitoring system for seal failure detection. Seals must be capable of withstanding rotation in either direction. A detector shall indicate when moisture is leaking past the first seal.

(d) Impeller shall be non-clog enclosed type with smooth blunt edges and large water ways so as to allow free passage of the large size solids. It shall be free from sharp corners and projections likely to catch and hold rags and stringy materials.

(e) The critical speed of the rotor shall be at least 30% above the operating speed. The pump shut off head shall be minimum 110% and maximum 130% of the rated pump head.

(f) Pump-sets shall have double bearings. Bearings shall be of the anti-friction type. Bearings shall be capable of taking the static weight of the rotating parts and any thrust generated by the pump's operation. The bearing life shall be a minimum of 100,000 hrs. of operation.

(g) Each pump shall be complete with a cast iron delivery connection arrangement for fixing to the concrete floor of the suction well. The joint between the pump discharge flange and the delivery piping shall be made by merely lowering the pump into guide rails / rope from access level. It shall be provided with all necessary fixings for guiding the pumps during lifting/lowering. Each pump shall be provided with a SS 316 lifting chain conforming to BS 1663 and BS 4942.

(h) Each pump shall be provided with an automatic coupling device for attaching to the duck foot bend base at low level by using lifting chain SS 316 and guide rail SS 316, even whilst the pump is submerged, without the need for personnel to enter the well. This automatic coupling device shall easily and automatically couple and uncouple from the duck foot bend base and be complete with necessary accessories. All links and cables shall be multi-stranded stainless steel.

(i) The materials of construction for submersible pumps shall be as follows:

S. No.	Component	Material
(i)	Impeller *	Stainless Steel: ASTM A 743 CF8M
(ii)	Casing *	Cast Iron to IS:210 Gr FG 260
(iii)	Mechanical seal (Motor side and Pump side) *	oil-lubricated with tungsten carbide or silicon-carbide faces
(iv)	Shaft*	Stainless Steel: BS:970 Gr 431/420
(v)	Bush*	Bronze IS 318 Gr. LT B2
(vi)	Guide rail pipe	Stainless Steel: BS:970 Gr 316
(vii)	Lifting Chain	Stainless Steel: AISI 316
(viii)	Fasteners and Foundation Bolts	Stainless Steel AISI 316

* Material test certificates from a government-approved metallurgical laboratory shall be furnished by the Contractor.

(j) Each pump shall be tested at the manufacturer's premises for the full operating range of the pump to BS 5316 Part 1. Pump performance shall be within the tolerance limits specified in the above BS.

8.4 Submersible Vertical Propeller Pumps

Application where larger volumes must be pumped up to relatively low heads Vertical Propeller Tube Type pumps should be used. Tube shall be of SS 316 material with minimum 8 mm thick.

Design Requirements

(a) Pump

(i) Pumps shall be compact, single stage, submersible propeller, vertical shaft, wear resisting, designed to install vertically in a Stainless-steel tube with an automatic coupling, suitable for screened sewage applications.

(ii) Pumps shall be designed for continuous operation under submerged conditions as well as intermittent operation.

(iii) Pumps shall be fitted with dynamically balanced non-clog propellers designed to pass coarse solids of at least 50 mm diameter.

(iv) The equipment shall be capable of developing the required total head at rated capacity. Total head capacity curve shall be continuously rising from minimum head to maximum head.

(v) Pump operating speed shall be less than 1000 rpm.

(vi) Pumps shall run smooth without undue noise and vibration. The velocity of vibration should be within 4.5 mm/sec. The noise level should be limited to 85 dBA at a distance of 1.86 M.

(vii) Pump should be equipped with double mechanical seals. Lower sealing between Impeller and Oil chamber and upper sealing between Oil chamber and motor winding.

(b) Submersible Motor

(i) Motor should be water pressure tight encapsulated, fully flood-proof motor, 3 phase Squirrel Cage Induction Motor, 415V +/-10%, 50 Hz, with IP-68 Enclosure with Class H/F Insulation, Temperature Rise: according to class B, IE3 Premium Efficiency Motor accordance with IEC60034-30.

(ii) Water pressure sealed connection chamber, with two-stage cable entry, protected against excessive cable tension and bending. The cable shall be EPR-insulated, Double sheathed, designed and certified for permanent use in sewage water, and suitable for a conductor Temperature of 80 °C.

(iii) Motor should be of low temperature rise so that it allows for a high service factor. Minimum service factor should be 1.3. 30% safety margin against overheating when a motor is operated under full load:

- At low line voltage
- At generator sets, which are slightly over speeding.
- In a medium with a temporarily higher temperature.

(iv) The propeller pump pumps the liquid upward in the steel pipe, which then flows around the motor. With this action, motor cooling happens automatically.

(v) All Motors shall be compatible with VFD operation.

(vi) The installed power rating of the motor should be larger than 115% of the power required at the duty point.

(vii) Bi-metallic thermal sensors should be provided in each phase of the motor winding and both bearings (upper and lower) to monitor temperature rises in the motor windings and bearings. The sensors shall be connected in series and shall be coupled to the motor contactor coil such that anyone-switch opening will shut down the motor.

(viii) Moisture sensors should be provided in the motor housing, mechanical seal oil bath & connection chamber of the motor. Moisture Sensors with an electronic amplifier trip the Motor in case of ingress of water.

i. For Oil chamber - To detect the Mechanical Seal Failures.
ii. For Motor housing - To monitor leaks in Motor housing.
iii. For Connection Chamber - To detect failure through Cable entry.
iv. Mating surfaces shall be watertight and fitted with nitrile O-rings.

(c) Features of Construction

The pump should be a Vertical Shaft, wear-resistant, single-stage, submersible Propeller type, suitable for screened sewage applications.

Pumps should be identical and suitable for parallel operation with equal load division. Components of identical pumps should be interchangeable.

Pump casing should be of robust construction. Liquid passages should be finished smooth and designed so as to allow free passage of solids as specified below.

Axial propeller with 3 or 4 propeller blades and diffuser on discharge side. Pumps should be provided with anti-friction ball or roller type bearings, lubricated-for life, maintenance-free designed for a L10 bearing life of 100,000 hours at BEP and shall be of enough size to transfer all radial and axial loads to the pump housing and minimize shaft deflection. Maximum shaft deflection should be 0.05 mm at mechanical seal face.

Pump should be furnished complete with coupling ring for welding in the steel pipe to hold the pump in steel tube, Lifting chain, Power & Control Cable, Motor control system, control panel and level switches.

For lifting the pump, a Stainless Steel Lifting hoop/handle should be fitted on the motor top.

All mating surfaces of the pump and motor shall be machined and fitted only with O-rings (NBR) where watertight sealing is required.

The pump should be equipped with double mechanical seals. Lower sealing by means of a SIC/SIC between Impeller and Oil chamber, and upper sealing by SIC/SIC mechanical seal between Oil chamber and motor winding, independent of the direction of rotation.

The propeller and the Rotor shaft should be dynamically balanced.

The Pump set shall be capable of withstanding the accidental rotation in the reverse direction.

Description	**Material of Construction**
Cooling/oil chamber, Connection chamber, Motor housing, Diffuser / Inlet Diffuser	CI IS 210 Gr. FG.260
Shaft	Stainless Steel AISI 431/420
Propeller Blades	SS ASTM A 743 Gr.CF8M
O-ring/Seals	Nitrile rubber (NBR)
Fasteners	SS 316
Lifting Chain	SS 316

8.5 Chemical Feeding Equipment

8.5.1 Chemical Dosing Pumps

(a) Chemical dosing pumps shall be of the piston diaphragm or mechanical diaphragm type as specified. Pumps may be arranged in simplex or duplex arrangements to suit the capacity or process requirements. The pump design shall incorporate positive stroke return. The maximum stroking speed shall not exceed 100 strokes per minute (spm). Pump, motor and driving arrangement shall be mounted on a robust combined baseplate.

(b) Pump liquid ends shall be selected for compatibility with the pumped liquid. Suction and discharge valves shall be the single ball type allowing a free flow self-cleaning action. Ball and seat materials shall be resistant to abrasion.

(c) Pumps shall incorporate a variable stroke mechanism to allow the output to be varied while the pump is running. Stroke adjustment shall be manual or, where specified, by an electrical or pneumatically controlled stroke positioner. A stroke length indicator and digital stroke counter shall be fitted. Pumps shall be driven by a flange-mounted IP55 motor, via an oil-bath reduction gearbox and a variable stroke mechanism, providing stepless adjustment between zero and maximum stroke length. Where flow proportional dosing is required the variation of output shall be achieved by varying the speed of the pump motor and not the pump stroke length.

(d) The normal operating range of the dosing pump shall be not less than 6:1.

a. Mechanical Diaphragm: Diaphragm rigidly coupled to the drive train. Single suction Pumps and discharge valves. Glandless. Accuracy: ± 3% of stroke.

b. Piston Pumps : Cylinder and piston with packed gland. Double-suction and discharge valves can be fitted for greater accuracy at high pressures. Accuracy: ± 1% of stroke.

c. Piston Diaphragm Pumps: Diaphragm hydraulically operated by liquid displaced by a plunger and protected from excess pressure via a relief valve. Accuracy: ± 2% of stroke.

Materials shall be selected to suit the chemicals being pumped. Liquid ends shall be polypropylene, 316 stainless steel, glass, or Hastelloy C. Diaphragm materials shall be butyl rubber, PTFE, or Hypalon and glands shall be PTFE or Neoprene.

(e) Each pump shall be provided with inlet and outlet isolating valves and with pressure relief and non-return valves. On the suction side, a Y-type strainer shall be provided for each pump set. Dosing pumps shall be provided with back pressure loading valves and pulsation dampeners in the delivery lines.

(f) A relief valve shall be incorporated in the delivery lines under conditions where the pump discharge pipe can be shut off or where pressure may rise to an excessive point. The relief valve

shall be sized to handle the system pressure and to discharge maximum pump output freely and shall be located in the discharge line between the pump and the first downstream isolating valve or in the case of dosing pumps the back pressure loading valve. Relief valves when used on pumps handling non-hazardous chemicals shall discharge the vented liquid to waste. When used on hazardous chemicals the valve outlet shall be piped back to the suction supply tank or bunded area. The open end of the return pipe shall be located in a visible position, allowing for the detection of any relief valve leakage or operation. Pump transferring/dosing chemicals to systems under pressure shall incorporate a pressure gauge on the pump delivery. Air cocks shall be provided for release of air where necessary.

(g) Unless otherwise specified flushing connections shall be provided at each pump inlet and flushing shall be manual. When flushing, water shall be discharged either locally through a drain valve or to the point of application of the chemical. Facilities shall also be provided for flushing chemical pump suction and delivery manifolds and delivery lines to point of application.

(h) Dosing pumps and motors shall preferably incorporate an integral reduction gearbox drive that is totally enclosed, and oil-bath lubricated. The gearbox shall incorporate cams for the diaphragm drive and shall be equipped with filling and drain connections, as well as a visible oil level indication.

(i) All dosing pumps shall have facilities/terminals for pulse input and output (4-20 mA) to facilitate online control via the plant's PLC and SCADA.

8.5.2 Chemical Tank and Mixer

(i) General

This tank shall be used to dissolve the alum or polymer to a constant concentration and feed the solution to the outlet channel of the aeration tank or the dewatering equipment. It shall be a vertical tank and shall be composed of tank main body, mixer, manhole, electrical level gauges, direct reading level gage, ladder, air exhaust pipe etc.

(ii) Fabrication

(a) The tank shall be made of corrosion-resistant material.

(b) The tank shall be provided with a removable cover to prevent chemical scattering, and also with a vent pipe.

(c) The tank shall be provided with necessary mounting seats for the overflow pipe, the drain pipe to the nearest drain point, etc.

(d) The motor-driven mixer shall be a vertical speed reducer, a direct-coupled type of 2-stage propeller type, as a rule, and shall be constructed to endure continuous operation free from vibration, etc. The mixer shall be at the centre or at a position off the centre according as the tank being angular or circular.

(e) The mixer shall be protected by electrical prevention of dry operation and controlled by timer.

(f) The tank shall be constructed to seal gas and splash from below at the area where the mixer shaft drive portion passes through.

(g) Alum feed cage of stainless steel shall be provided inside the alum solution tank.

(iii) Materials

(a)	Main Tank body	: GRP/HDPE
(b)	Mixer frame	: SS316
(c)	Mixer shaft	: SS316
(d)	Blade	: SS316L

(iv) Accessories (per Unit)

(a)	Foundation bolt and nut	x 1 set
(b)	Air vent pipe	x 1 set
(c)	Mixer	x 1 unit
(d)	Direct reading level gauge	x 1 unit

8.5.3 Alum Dispersion Flash Mixer

The flocculant injection facility shall be constructed to inject the flocculant into the outlet side of the A2O aerobic tanks to reduce the phosphorus in the treated wastewater.

The location where flocculant is injected should consider the contact time required for effective phosphorus removal.

- Consider that the injection method shall be appropriately injected according to the type and properties of the flocculant used.
- The flocculant shall be selected in consideration of the effect on nitrifying bacteria.
- The flocculant injection facility shall be equipped with an overturn prevention and automatic control device.
- The injection volume should remain stable from the maximum to the minimum injection volume.
- Chemical storage tanks, dissolution tanks, and mixers shall be made with corrosion-resistant materials.
- The capacity of the chemical storage tank and the capacity of the dissolution tank shall be considered for work efficiency.
- For the infusion pump, select a model that can inject stably and is corrosion resistant.
- Injection pumps shall be selected that are easy to maintain.
- The injection pumps and dissolution mixers should be linked to the water level gauge in the chemical tank to prevent operation when the tank is empty.
- Water facilities shall be provided for dissolving chemicals.
- The injection piping shall be selected from materials that can withstand corrosion and injection pressure.

- The injection equipment shall be equipped with an electromagnetic flow meter, pressure reducing valves, strainers, check valves, pressure gauge, diaphragm valves, bypass valves and drain valves.
- A water washing pipeline shall be installed in the chemical injection piping.
- Concrete breakwater shall be installed around the chemical storage tanks.
- Drain pits, drainage pumps, cleaning water piping equipment, and ventilation equipment shall be provided in the chemical injection room.
- Platforms, stairs, and handrails shall be made of corrosion-resistant materials.
- The mixing chambers shall be of reinforced concrete. The inlet to the mixing chambers shall be designed to provide an equal distribution to each unit. The outlets of mixing chambers leading to the secondary clarifier shall be provided with electrically operated sluice gates. The freeboard shall be at least 50 cm.
- A flash mixer shall be used to intimately mix the Alum and the aerated sewage as rapidly as possible. One flash mixer shall be provided for every unit located before the flow is split to the secondary clarifier distribution chamber.
- The flash mixer shall be a stirred tank constructed from reinforced concrete, rectangular in cross-section. Each Chamber shall be connected to the drainage system by means of pipe and gate valve.
- The flash mixer design shall be such that short-circuiting is minimized and the coagulant is thoroughly mixed with the water at the outlet of the flash mixer.
- The mechanical equipment for flash mixers shall comprise stainless steel (SS-316L) agitating paddles fixed on stainless steel (SS-316) shaft with thrust bearing support, driving gear consisting of a motor coupled to a reduction gear of appropriate ratio.
- The motor and gearbox arrangement shall be covered and any spillage of oil from the gearbox shall be prevented from entering the aerated sewage.
- The Flash Mixer installation area shall be provided with Monorail and Hoists facility for handling of the Flash Mixers and the accessories.

8.6 Induction Motors

8.6.1 Design Requirements

The motors shall be suitable for operating on a 415 V, 50 Hz, 3 phase, Ac supply.

The motors shall generally conform to IS: 325 or relevant equivalent internationally approved standards. Additionally, the specific requirements mentioned in the following clauses shall also be met. All motors shall be IE 3 energy efficient type.

8.6.2 Performance and Characteristics

(a) Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions:

(i)	Variation in supply voltage	$\pm$ 10%
(ii)	Variation in supply frequency	$\pm$ 5%

(iii) Combined voltage and frequency variation ±10%

(b) Motors shall be suitable for full voltage direct-on-line starting or star delta starting. Minimum permissible starting voltage shall be 85% of the rated voltage.

(c) The Power rating of the motor shall be the larger of the following:

(i) 115% of the power input to the pump at the duty point at a speed corresponding to the frequency of 50 Hz.
(ii) Maximum power input while operating single pump corresponding to the speed of 50 Hz.

8.6.3 Insulations

Any joints in the motor insulation such as at coil connections or between slot and winding sections, shall have strength equivalent to that of slot sections of the coil. The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot, humid and tropical climate. The motors shall be provided with class F insulation with temperature rise limited to that of class B insulation. The degree of enclosure protection of motors shall be of minimum IP 55.

Motors shall be given power house treatment. This comprises an additional treatment to the winding over and above the normal specified treatment. After the coils are placed in slots and all connections have been made, the entire motor assembly shall be impregnated by completely submerging in a suitable insulating compound or varnish followed by proper baking. At least three such submersions and backings shall be applied to the assembly.

8.6.4 Constructional Features

The motor construction shall be suitable for easy disassembly and reassembly. The enclosure shall be sturdy and shall permit easy removal of any part of the motor for inspection and repair.

a) Motors weighing more than 25 kg shall be provided with eyebolts, lugs or other means to facilitate safe lifting.
b) The rotor bars shall not be insulated in the slot portion between the iron core laminations for squirrel cage motors.

8.6.5 Terminal Box

Terminal boxes shall be of weather proof construction designed for outdoor service. To eliminate entry to dust and water, gaskets of neoprene or approved equivalent shall be provided at cover joints and between box and motor frame. It shall be suitable for bottom entry of cables. It shall be capable of being turned through 360 degrees in steps of 90 degrees.

The terminals shall be of the stud type with necessary plain washers, spring washers and check-nuts.

They shall be designed for the current carrying capacity and shall ensure ample phase to phase and phase to ground clearances. Suitable cable glands and cable lugs shall be supplied to match specified cables.

Separate terminal boxes shall be provided for the following:

(i) Starter leads; and

(ii) Space heater

8.6.6 Accessories

Two independent earthing points shall be provided on opposite sides of the motor, for bolted connections. These earthing points shall be in addition to the earthing stud provided in the terminal box.

8.6.7 Heating during Idle Period

For motors rated below 7.5 kW, during idle periods, the stator winding will be connected to a required single phase, 50 Hz, AC supply for heating and elimination of moisture. The supply will be connected between any two terminals.

Motors rated 7.5 kW and above shall have space heaters suitable for 230V, single phase, 50 Hz, AC supply. Space heaters shall have adequate capacity to maintain motor internal temperature above the dew point to prevent moisture condensation during the idle period. The space heaters shall be placed in easily accessible positions in the lowest part of the motor frame.

8.6.8 Earthing Pad

Two independent earthing pads of non-corrodible metal shall be welded or brazed at two locations on opposite sides, complete with suitable bolts and washers for earthing. These earthing pads shall be in addition to earthing stud provided in the terminal box.

8.6.9 Rating Plate

The following details, in addition to those specified in applicable standards shall be included on the rating plate.

Rated voltage, Type of motor, Type of connection, kW rating, frequency, efficiency, power factor, temperature rise of windings in degree centigrade at rated load, and ambient conditions.
Type of bearings, recommended lubricant, lubricating interval & re-lubricating quantity.

8.6.10 Tests

Motor shall be subjected to all the type tests (one from similar rating of each lot) and routine tests as per applicable standard in the presence of the Engineer. Copies of test certificates for all brought out items shall be furnished at the time of inspection for the Employer’s approval. The Contractor shall ensure to

use calibrated test equipment / instruments having valid calibration test certificates from standard laboratories traceable to National / International standards.

8.6.11 Low Voltage Motors

Motors shall be suitable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is 85% of the rated motor voltage.

The locked rotor current of the motor shall not exceed 600% of the full load current (subject to tolerance as specified in the applicable standard).

Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation.

Stator leads shall be brought to the terminal box as insulated cable through a suitable barrier and terminated in clamp type terminals.

Motors shall be equipped with smart sensors for condition monitoring, enabling predictive maintenance. Condition monitoring enables the planning of maintenance activities, reducing downtime and supporting longer motor lifetimes. At the same time, the solution generates big data on the status of large numbers of motors, paving the way for predictive operations and optimized energy consumption.

The sensor monitors signals from the motor, accurately measuring key parameters at regular intervals, and transfers the data, converting it into meaningful information. This information is then sent to the user's smartphone and customer portal via built-in Bluetooth Low Energy technology, which connects to a smartphone or gateway and a secure cloud-based server.

The smart sensor shall measure the following parameters:

i) Overall motor condition
ii) Overall vibration
iii) Bearing condition
iv) Misalignment
v) Skin temperature
vi) Output power, operating hours, number of starts, and speed.

Motors rated 7.5 kW and above shall be provided with space heaters with adequate capacity to maintain motor temperature to prevent moisture condensation on the insulation during idle condition. The space heaters shall be suitable for a 240V single-phase 50 Hz supply. The degree of enclosure protection of motors shall be a minimum of IP 55.

8.6.12 HV Motor (For Process Air Blowers)

Motors shall be capable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is 80% of the rated voltage.

(a) Motors shall be capable of satisfactory operation at full load at a supply voltage of 80% of the rated voltage for 5 minutes, commencing from hot condition.

(b) The locked rotor withstand time under hot conditions at 110% rated voltage shall be more than starting time at minimum permissible voltage by at least two seconds or 15% of the accelerating time whichever is greater. The locked rotor current of motors shall not exceed 600% of full load current of motors which is inclusive of 20% tolerance.

(c) Motors when started with the drive imposing its full starting torque under the specified supply voltage variations shall be capable of withstanding at least two successive starts from a cold condition and one start from a hot condition without injurious heating of windings. The motors shall also be suitable for three equally spaced starts per hour under the above-referred supply conditions.

(d) The three phases shall be segregated by metal barriers within both line and neutral Terminal box.

(e) The earthling pads shall be of non-corrodible metal, welded/brazed at two locations on opposite sides. The pad size shall be 75 x 65 x 25 mm with two holes drilled at 40mm centers, tapped & provided with suitable bolts and washers for connecting the earthling strip.

(f) At least six resistance type temperature detectors for the stator winding each having D.C. resistance of 100 ohms at 0 degrees Celsius, embedded in the stator winding at locations where highest temperatures may be expected, shall be provided. The material of the RTD's shall be platinum.

(g) At least one vibration detector for the stator winding, embedded in the stator winding at location where vibration may be expected, shall be provided. Compression-type piezoelectric accelerometers, velocity transducers, or proximity transducers should be used in the vibration detection system.

(h) Motors shall have space heaters suitable for 240V single phase 50Hz AC supply. These shall be placed in easily accessible position in the lower part of motor frame. Provision shall be made to measure the bearing temperature by inserting a handheld temperature measuring device.

(i) Motors shall have drain plugs so located that they will drain water, resulting from condensation or other causes from all pockets in the motor casing.

8.6.13 Induction Motor (Submersible Pump & mixer)

Performance and Characteristics

a) The submersible motor shall conform to IS: 9283 and the submersible cable shall conform to IS: 9283. The motors shall be suitable for operating on a 415 V, 50 Hz, 3 Phase, Ac supply.

Pump motor shall be of the squirrel cage submersible type, protected to IP 68. Motor for submersible pump shall be capable of startup and operation in the event of a completely flooded wet well. Motor cooling for submersible pump must be achieved by internal cooling jacket, using the glycol water to cool the motor. This motor shall be capable of starting 10 times per hour. The insulation class of motor winding shall conform to class F/H as specified in the pump or mixer specification. Additionally, the specific requirements mentioned in the following clauses shall also be met. The motor shall be the most energy-efficient type.

b) Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions:

(i)	Variation of supply voltage from rated motor voltage	±10%
(ii)	Variation of supply frequency from rated frequency	±5%
(iii)	Combined voltage and frequency variation	±10%

The starting current of the motor shall not exceed 300% of the rated full load current for soft starter starting and 600% of the rated full load current for DOL starting, under any circumstances.

Motors shall be suitable for full voltage direct-on-line starting or soft starter starting.

Motors shall be capable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is in the range 85% of the rated motor voltage to maximum permissible voltage.

The locked rotor current of the motor shall not exceed 600% of full load current (subject to tolerance as per the applicable standard) unless otherwise specified.

Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation. The motor vibrations shall be within the limits specified in applicable standard unless otherwise specified for the driven equipment.

Except as mentioned herein, the guaranteed performances of the motor shall be met with tolerances specified in applicable standard, IS: 9283.

Motor insulation shall conform to Class F/H as specified in the pump or mixer specification and the maximum temperature rise shall be limited to class B. The motor windings shall be protected with a waterproof material and shall incorporate a thermal sensor in each phase to safe guard against high winding temperatures. The thermal sensor shall be connected into the control circuit of the starter and signals taken for continuous monitoring of winding temperatures. The motor shall incorporate a cut out device to detect the presence of any liquid in the motor enclosure, in the form of non-resetting moisture switch. The terminal connections for the power and protective circuits shall be housed in a completely

sealed and water proof junction box, complete with all external corrosion resistant cable glands. The pump units shall be provided with power and protection circuit cables of sufficient length to reach from the motor junction box to the local isolator located at the panel floor level.

Protection against increase in stator winding temperature bearing temperature, leakage in stator housing and terminal box shall be provided. Minimum three number thermistors are to be provided to sense the stator winding temperature. Sensors are to be provided to detect if the leakage of sewage into the oil housing is above 30 % concentration.

Bimetallic thermal switch to trip the motor against increase in temperature shall be provided.

The power rating of the motor shall be larger of the following:

(i) 115% of the power input to the pump at duty point at a speed corresponding to the frequency of 50 Hz.

(ii) Maximum Power input while operating single pump corresponding to the speed of 50 Hz.

Motor shall be offered for routine and type tests in accordance with IS: 4029 and IS: 325 at the manufacturer's works.

8.6.14 Submersible Cable

(a) The submersible cable shall conform to IS: 9283. The power cable shall be PVC insulated and PVC sheathed, flexible, 3 core or 4 core flat type with insulated leads. The size of the conductor shall be adequate for continuous use under water and air. The fourth core shall be used for earthing. The motor cable length shall be as per site requirement.

(b) The control cable shall be PVC insulated PVC sheathed, flexible, flat type and shall be adequate for continuous use under water and air. The control cable for stator winding temperature sensor (Thermistors) 3 core x 2.5 sq. mm copper conductor and for bimetallic thermal switch 2 core x 2.5 sq. mm copper conductor shall be provided.

(c) In case a joint is required to be made between the lead cable supplied with the motor and the user's cable connectors, a detailed procedure of cable jointing to make a watertight joint shall be provided by the manufacturer.

(d) The size of the conductor and length of cable should be suitably selected so that the voltage drop at motor terminals does not exceed 3 percent of the rated voltage.

(e) Cable Glands shall generally be of the mechanical double compression hexagon type Earth continuity of brass glands shall confirm to BS: 6121 / EN 50262. This may be achieved by the

rigid clamping of the armour within the gland and the intimate contact between the threaded components of the gland and the equipment.

(f) Each gland shall be installed complete with proprietary earth tag providing a ready means of connecting a flexible strand or strip earth bond to the gland at any position around the gland in relation to the associated apparatus. Adequate earth continuity shall be assured between the earth tag, the gland and the armour wires of the cable where applicable.

(g) Each gland shall be installed complete with a proprietary non-ferrous lock-nut to secure the gland body to the equipment where the entry hole is plain, i.e. not tapped.

(h) Earthing

Earthing of the motor shall be done in accordance with the relevant provisions of IS: 3043. For the purpose of earthing these motors, earthing connection may be made to discharge pipe. All the materials and components for the motors shall be suitable for application in respect of corrosion resistance and mechanical performance continuously under water.

8.6.15 Insulation

(a) Any joints in the motor insulation such as at coil connections or between slot and end winding sections, shall have strength equivalent to that of the slot sections of the coil.

(b) The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot, humid and tropical climate. The tropicalising treatment shall be as per the applicable standard.

(c) The stator winding shall be made from high conductivity annealed copper conductor, PVC insulated winding wires conforming to IS: 8783 for wet type motors. The stator winding shall be of high conductivity annealed copper enameled insulated wires conforming to IS: 4800 (Part-VII) for dry type motors.

8.6.16 Temperature Rise

The temperature-rise test of the motor shall be carried out with the motor coupled to the suitable pump as per relevant standard.

8.6.17 Constructional Features

The motor shall be suitable for continuous use in fully or partially submerged condition. A built-in cooling system must allow the motor to operate continuously at its rated output regardless of whether the electric motor is submerged or not, by providing either external or internal cooling arrangement.

8.6.18 Terminal Box

Terminal box shall be of weather proof construction to eliminate entry of water and dust.The terminals shall be of the stud type with necessary plain washers, spring washers and check nuts. They shall be substantially designed for the current carrying capacity and shall ensure ample phase to phase and phase to ground clearance.

8.7 Sluice Gate & Weir Gates

8.7.1 Cast Iron Gate:

(a) Design Requirements and Construction Features

The construction of sluice gates shall be in accordance with the specification and generally as per IS: 13349. All sluice gates shall be of the rising spindle type.

(b) Frame

The frame shall be of the flange back type and shall be machined on the rear face to bolt directly to the machined face of the wall thimble.

(c) Seating Faces

Seating faces shall be made of full width, solid section; dove-tail strips of stainless steel. They shall be secured firmly by means of counter sunk fixings in finished dove-tail grooves in the frame and slide faces in such a way as to ensure that they will remain permanently in place, free from distortion and loosening during the life of the sluice gates.

(d) Wedging Devices

Sluice gates shall be equipped with adjustable side, top and bottom wedging devices as required providing contact between the slide and frame facing when the gate is in closed position.

(e) Lifting Mechanism

(i) Sluice gate shall be operated through suitable lifting mechanism which shall incorporate suitable gearing if required, to keep the torque requirement within 7 kg. m.

(ii) Lifting mechanism shall incorporate a strong locking device suitable for use with a padlock or padlock and chain.

(iii) Lift mechanism shall be provided with a suitable position indicator to show the position of the gate at all times.

(f) Wall Thimbles

The cross section of the thimble shall have the shape of the letter 'F'.

(g) Lifting Lugs

Lifting lugs shall be provided for all gates.

(h) Flush Bottom Seal

(i) When sluice gates are provided with flush bottom seals, the wedging device and facing along the bottom edge of the slide and frame shall be omitted.

(ii) A solid square cornered, resilient rubber seal shall be provided on the bottom facing of slide. The seal shall be securely fastened to the bottom face of the slide by a retainer bar and corrosion resistant metal fasteners. The top surface of the bottom facing of frame shall be flush with invert of the gate opening. Bottom facing of the slide shall be accurately machined to contact the seal when the slide is closed.

(i) All the sluice gate and weir gate shall be operated by portable type of electric actuators except at the disc filtration unit which shall have permanently fixed electric actuator with modulating type.

(j) Two nos. Portable type Electric actuator shall be provided for opening and closing of sluice gates, so that the closing and operation time shall be maximum of 10 minutes in each Sewage Treatment Plant and in each ISPS campus.

(k) Provision of safety stop nut on spindle to prevent the chances of over-closing of gate, which may otherwise damage either the spindle or the lifting platform.

(l) The material of construction of sluice Gate shall be as follows:

S. No.	Component	Material
(i)	Wall Thimble	Cast Iron: IS 210 Gr. FG 200
(ii)	Frame and Slide	Cast Iron: IS 210 Gr. FG 200
(iii)	Seating faces	Stainless Steel: ASTM Countersunk fixing A276 type 316
(iv)	Wedge	Stainless Steel: ASTM A743 CF8M or SS316
(v)	Stem	Stainless Steel: ASTM extension A276 type 316
(vi)	Stem nut	Stainless Steel: ASTM A743 CF8M
(vii)	Stem Coupling	Stainless Steel: ASTM A276 type 316
(viii)	Fasteners, anchor	Stainless Steel: ASTM bolts and nuts A276

S. No.	Component	Material
		type 316
(ix)	Lifting mechanism, Pedestal gear house cover and stem guide	Cast Iron: IS 210 Grade FG 200
(x)	Lift nut	Bronze: ASTM B 148 (CA952, CA954 or CA958)
(xi)	Stop nut	Bronze: ASTM B 148 (CA952, CA954 or CA958)

8.7.2 Modulating Sluice Gate:

It shall be as per IS: 13349

Wall thimble mounted Sluice gates shall be used for isolation of flow from a chamber to a closed conduit. It shall be suitable for modulation application.

Salient Features:

- It shall be of flange back frame gate suitable for mounting on the face of a Cast iron Wall thimble using studs and with a gasket between gate frame and wall thimble flange.
- Wall thimble shall have cross section "F" and depth of 300 mm. Gates having square / rectangular opening to be provided with thimble having square/ rectangular opening aperture with square / rectangular flange for gate frame mounting.
- It shall have Square/Rectangular shaped natural rubber Gasket with predrilled holes for positioning in between machined face of wall thimble flange and frame flange.
- It shall have open top frame provided with short length extension guides to support ½ vertical height of the slide when the slide is in full open position.
- Frame will be provided with liners for modulating duty application.
- Frame specially designed to permit front access for tightening of thimble mounting nuts so as to enable mounting of gates side by side or near corners.
- Rigid shutter designed to withstand the applicable water head. Shutter to be provided with cast integral pocket to house the stem-connecting block, which connects the spindle to the shutter for up and down operation.
- Seat facing fitted on machined plain surface of frame and shutter-using counter sunk screws for better fitments.
- The type of bottom closing offered is Flush bottom closing (FBC). In flush bottom closure gates, sealing to be metal to rubber for bottom side and metal-to-metal on balance three sides.

- Adjustable type individual side wedging arrangement for gates meant for seating water head application and adjustable type individual side as well as top & bottom wedging arrangement for gates meant for unseating water head application.

- Adjustable Channel type stem guide brackets in requisite quantity to prevent buckling of spindle in event of over-closing of gate.

- Rising stem / spindle to suit the distance between centerline of gate opening and top of operating platform as stated below in price schedule. The spindle shall be provided with square / trapezoidal threading with the threaded length being approximately 400mm more than the height of waterway opening.

- Spindle couplings to connect multiple stem / spindles in case the maximum length of one-piece stem / spindle exceeds 4.5 to 5 meters resulting in the need for more than one stem / spindle.

- Rising spindles are provided with Stem cover of Polycarbonate tube to protect spindle threads from effect of dust, dirt and weather.

- Rising spindles are provided with gate opening indicating arrangement to indicate the position of shutter.

- Provision of safety stop nut on spindle to prevent the chances of over-closing of gate, which may otherwise damage either the spindle or the lifting platform.

- Lift mechanism mounted on separate platform above gate frame so that gate operating thrust comes on to the platform.

- Operation of gate by means of electric lift mechanism comprise of pillar mounted Electric Actuator with manual override unit. These actuators should have an inbuilt with local control push buttons and suitable for modulating application.

SI. No.	**Part Description**	**Materials of Construction**
a	Frame & Shutter	CI IS: 210 Gr. FG 200
b	Wall Thimble	CI IS: 210 Gr. FG 200
c	Seating Faces & Counter Sunk Fixing	Stainless Steel ASTM A240 type 316
d	Wedging Device (with SS 304 Linings)	CI IS: 210 Gr. FG 200
e	Stem, Stem Extension & Coupling	Stainless Steel ASTM A276 type 316
f	Stem Block	Stainless Steel ASTM A743 CF8M
g	Fasteners, Anchor Bolt, Studs & Nuts	Stainless Steel ASTM A276 type 316
h	Lifting Mechanism, Pillar, Head Stock	CI IS: 210 Gr. FG 200

SI. No.	Part Description	Materials of Construction
i	Stem Guide	CI IS: 210 Gr. FG 200
j	Stem Guide Bracket	Structural steel
k	Stem cover with Indicating Arrangement	Polycarbonate Tube
l	Lift Nut	Bronze IS: 318 Type LTB-2
m	Stop Nut	Bronze IS: 318 Type LTB-2

8.7.3 Mechanically Operated Stoplogs

The construction and general design of Stainless Steel Stoplogs shall be in accordance with the specifications mentioned here under. They shall be so constructed that there is no undue wear or deterioration during its operative life and so designed that the maintenance is kept to a minimum.

The stoplogs shall be capable of performing the isolation duties in waste water treatment plant and pumping stations for those applications where the side water depth is at least 300 mm less than the height of stoplogs.

The stoplogs as well as stoplog frame shall be made of extruded sections and not fabricated so as to keep welding to minimum.

The Stoplogs shall be designed for seating water pressure equal to the height of the top most log.

The Stoplogs shall have an on-seating leakage rate of not more than 1.25 liters / minutes / meter length of sealing perimeter.

The Stoplogs shall be supplied along with all accessories such as Stoplogs, lifting system, storage rack etc. and miscellaneous items like fasteners, gaskets, anchor bolts etc. required to erect and install these items.

Each Stoplog shall be manufactured as detailed hereunder and shall be supplied duly tested as per requirement. The Stoplog assembly shall be supplied as a factory assembled unit and shipped to site as a ready to install unit.

This assembly shall be uncrated at site and installed as complete assembled unit without stripping down into components. This is to ensure that the performance integrity of the stoplogs remains as factory tested and supplied condition, thus minimizing the influence of the installation process to achieve optimum performance at site after installation.

(a) Constructional Features

The constructional features and details of components of the required stoplogs are to be as under:

The stoplogs shall be made of an extruded section of Stainless steel material of grade 316 and having a minimum thickness of 5 mm. The sections used shall have adequate strength to prevent distortion during normal handling, installation and while in service.

The extruded stoplogs section shall be sufficiently rigid to withstand the designated water head. Maximum bending stress shall not exceed 7600 PSI at the maximum operating head.

The extruded stoplog section shall be designed for adequate and prompt drainage while removal.

The stoplogs shall be provided with lifting pins to enable lifting of stoplogs using mechanically operated lifting beam.

The total height of stacked stoplogs shall be approximately 300 mm above the maximum height of water.

The stoplog sectional height shall not be less than 250 mm and not more than 1250 mm so as to ensure that minimum sectional pieces are provided to achieve the required total height.

Stoplogs suitable for lifting manually using lifting rods should not weigh more than 50 kgs. to enable 2 persons to lift them and transfer to storage rack. Stoplogs suitable for lifting using mechanically operated lifting beam, which can engage / disengage automatically with lifting pins provided on logs, shall be so designed that the total lifting load does not exceed 1000 kgs. including the water pressure acting on the stoplogs.

The aluminium stoplogs shall be provided with minimum 120 micron thick coat of suitable epoxy paint to prevent oxidation of aluminium material.

(b) Stop log Frames

The stoplogs frames shall be made of extruded section of Stainless steel material of grade SS 316 and having a minimum thickness of 5 mm. The sections used shall have adequate strength to prevent distortion during normal handling, installation and while in service.

The stoplogs frames shall comprise of bottom invert section and two vertical side guide section for housing the stoplogs. The frames shall be suitable for embedment in two parallel walls on sides and in floor invert at bottom.

The vertical sides of the frame shall extend up to the top of the operating platform to facilitate the removal and insertion of stoplogs. For lengths above 3 meters the vertical side guides can be provided in sectional construction.

(c) Seals

The stoplogs sealing arrangement shall comprise a continuous resilient seal along the bottom and both sides to restrict leakage in accordance with the requirements listed in this specification. The resilient seals shall be of EPDM or Neoprene rubber as per ASTM D2000. The side seals shall be mechanically

retained and all the seals shall be easily replaceable. Seals fixed by gluing will not be accepted. The fasteners used shall be of stainless steel material as specified.

(d) Lifting Beam

Lifting beam shall be provided to insert and pull out the stoplogs using an electric hoist arrangement. If the hoisting weight of stoplog is over 50 kgs then suitable provision for handling the stoplogs with the lifting beam should be provided by the contractor. The lifting beam shall be designed to automatically engage with an installed stoplog and lift the same out of frame. The lifting beam also shall have arrangement to disengage the stoplogs by an operator standing on the platform. One lifting beam shall be provided for stoplog having same / equal width in the plant. The lifting beam shall be constructed of Carbon steel material with epoxy painted and shall be designed to lift a load of minimum 1500 kgs.

(e) Storage Rack

A movable storage rack shall be provided to house the stoplogs and lifting beam when they are not in use. The storage rack shall be of stainless steel. The storage rack shall be so designed that the resilient seals of the log shall not remain under compression during storage.

The material of construction for various components shall be as under:

Component	Material
Stoplogs & Frame	Stainless steel AISI 316
Resilient Seals	EPDM ASTM D2000
Rubber seal retainer bar	Stainless Steel ASTM A 240 type 316
Assembly bolts, nuts and fastener	Stainless Steel ASTM A 276 type 316

8.7.4 Weir Gates

The downward opening weir gates shall be manufactured from Cast Iron and shall be Flange back type suitable for wall mounting and manufactured in line with provisions of AWWA C-560 / IS 13349 with improvements as desired and specified hereunder for weir application.

The weir gates shall be capable of performing continuous weir duty in plant and shall be so constructed that there is no undue wear or deterioration during its operative life and so designed that the maintenance is kept to a minimum.

The weir gates shall be designed for water tightness at any level of opening for off-seating pressure equal to depth of shutter. The weir gates shall have off-seating leakage rate of not more than that permitted under AWWA-C560 / IS 13349.

All the weir gates shall be shop tested to verify the leakage performance at operating head, torque tested at operating head to verify the suitability of actuating mechanism and PMI tested to verify the correctness of the material used. This testing will be done in presence of client / client representative or approved third party inspection agency.

The weir gates shall be rising spindle type and the operation shall be by means of Manual / Electric operating mechanism.

The weir gate shall be supplied along with all accessories such as gates assembly, gasket between wall and gate assembly, studs and nuts for mounting on wall, stem connecting block, spindle, spindle couplings, spindle guides, pedestal, operating mechanism as required, gate opening indicating arrangement and required anchor bolts and fasteners for stem guides and pedestal.

The main gate assembly comprising of frame, guides and shutter will be supplied as a factory assembled unit and shipped to site as a ready to install unit on the wall. This gate assembly will be uncrated at the site and installed as a complete assembled unit without stripping down into components. This is to ensure that the performance integrity of the weir gates remains as factory-tested and supplied, thus minimizing the influence of the installation process on achieving optimum performance at the site.

(a) Constructional Details :

The weir gates shall be manufactured generally as per provision of AWWA C-560 / IS-13349 with suitable changes for weir application. The constructional features and details of components of the required gates shall be as under:

(b) Gate Frame

The gate frame will be made from cast iron and shall be sufficiently rigid to withstand the designated water head. The gate frame shall be flange back type to suit the designed head and site condition. Back flange of the gate aperture frame to be precisely machined flat and drilled to engage with the face wall. A rubber gasket will be provided between the wall and the gate for ease in future dismounting of the gate for repairs / replacement and seal any leakage between the flange of frame and the wall. The gate frame of these sluice gates shall either be self-contained type or non-self-contained type depending upon site requirement. In case of non-self-contained gates the frames shall be without yoke at their top. In case of self-contained gates the frames shall have extension guides of requisite length and shall be provided with a yoke at their top. The length of guides shall be sufficient to engage at least half the overall vertical height of door when the gate is fully lowered to open and shall be in accordance with the relevant provisions of AWWA C-560 / IS-13349.

(c) Gate Slide / Shutter/ Door

The gate slide / shutter will be made from cast iron and shall be sufficiently ribbed to withstand the designated water head. The gate slide / shutter will be provided with integral pocket to house the thrust nut used to connect the stem with the slide.

(d) Seating/Sealing Faces:

Seating face shall be of Stainless steel. The seating / sealing faces on door shall be secured in place using taper screws which cannot be mechanically removed after fitting on facings. The taper screws adopted for facings shall be of same material as that of the seat facings.

To enable continuous sealing at any level of opening of the downward opening weir gate so as to achieve precise level control, the full face of the shutter will be fitted with specified seating / sealing faces and the sealing faces on shutter will always be in full face contact with corresponding metal / resilient sealing arrangement mounted on frame perimeter.

The mating seating/sealing faces on the gate frame and door shall be precisely finished for proper contact. They should be so finished that the clearance or gap, if any, between the mating sealing faces does not exceed 0.1mm at any level of weir gate opening.

(e) Manual Gate Operating Headstock/Lift Mechanism

The operating headstocks shall be designed in such a manner as to permit the gate operation by a single Person under the specified maximum operating head with an effort of less than 18 Kgs. on the crank /hand wheel.

The headstock may be ungeared or geared type and the geared headstock may be either of single speed or of double speed, as might be necessary to make it convenient for one person to open or close the gate as fast as practicable. Two speed headstocks shall be supplied with gates requiring higher hoisting capacities. In this type of headstock the low speed is meant for crack opening the gate when the effort required to open the gate is maximum and the high speed is meant for further faster opening after the gate is crack opened.

Geared headstock shall be supplied with easily removable crank handle or hand wheel with a radius not exceeding 375 mm.

All the gears of geared headstock shall be kept completely encased in cast iron housing to protect them from damage, dirt, dust, water etc. and other atmospheric effects and thus ensure their smooth operation. Grease Nipples shall be provided for lubricating with grease.

Headstock meant for mounting on operating platform shall be supplied with a pedestal/floor stand to provide a convenient operating height of approximately 900 mm. The pedestal of the headstock shall be provided with a covered window opening to enable cleaning and greasing of stem threads.

(f) Lifting Spindle/Stem

The sluice gates shall be supplied with Rising type lifting spindles/stems. The stem shall be provided with acme / square threading, length of threaded portion being about 400 mm more than the height of waterway opening. This much extra length is required to allow for a minor variation of approximately 100mm on either side of the specified height of operating platform. Provision of safety stop nut on

spindle to prevent the chances of over-closing of gate, which may otherwise damage either the spindle or the lifting platform.

The design of stem will be done as per the provision in AWWA C-560 / IS-13349.

(g) Stem Block/ Thrust Nut

The rising type stem shall be connected to the door through a stem block/thrust nut housed in a ribbed pocket cast integral with the door. The bottom end of stem shall thread into the stem block and is locked in place by a set screw to prevent the stem from unscrewing. The Stem block shall be cast bronze or Gunmetal.

(h) Safety Stop Nut

The stem shall be provided with a safety stop nut to prevent the chances of over-opening of gate, which could result in the spindle unscrewing from the operating nut and falling of the shutter. The stop nut shall be furnished with a set screw for setting it in a fixed position after the gate is installed. Upon installation the safety stop nut should be set in such a way that its bottom remains about 1 to 2 mm away from the top of headstock, in gate open position. In case of stainless steel stem, the stop nut shall also be of stainless steel material of the same grade.

An adjustable stopper arrangement will be provided on the frame and this stopper will engage with corresponding arrangement on shutter so as to prevent over closure of the shutter.

(i) Stem Coupling

For ease in transportation and handling, the maximum length of a piece stem shall be limited to 5 meters. Where the stem is required to be furnished in more than one piece, threaded stem couplings shall be furnished to interconnect different sections of the stem. The couplings shall have provision for pinning after inserting into the threaded end of the stem. In case of a stainless steel stem, the couplings shall also be of the same grade of stainless steel.

(j) Stem Guide Bracket

Longer stems shall be provided with sufficient number of stem guides to prevent buckling of stem. The stem guide bracket to be provided shall be Adjustable Centre Type - wherein a separate stem guide is bolted on to the wall bracket. The stem guide shall be adjustable in the slots on wall bracket in a direction perpendicular to the face of wall. Wall bracket should also offers minor adjustment in the direction parallel to the wall. The stem guides shall have machine bored split journals to facilitate erection. The journal shall be lined with brass/gunmetal bush.

(k) Pipe Hood For Stem

A Pipe hood shall be provided on the top of headstock in case of rising spindle/stem gates to cover the spindle threads for protection against damage, dirt, dust, water etc. It shall be made of transparent fracture resistant polycarbonate material. The pipe hood shall have vent holes to prevent condensation.

(l) Gate Opening Indicating arrangement

Gate opening indicating arrangement shall be provided to indicate the position of the shutter. This shall comprise of scale mounted on the pipe hood and an indicator nut mounted on the rising spindle to show the extent of the opening and closing. The minimum scale graduation shall be 25 mm.

MATERIAL OF CONSTRUCTION:

The material of construction for various components shall be as under:

Component	Material
Gate frame, Shutter	Cast Iron to IS:210 Gr FG 200
Headstock, Stem Guides, Stem Guide Bracket	Cast Iron to IS:210 Gr FG 200
Seating faces,	Stainless Steel ASTM A 240 type 316
Rubber Seals	EPDM Rubber to ASTM D 2000
Rubber seal retainer bar	Stainless Steel ASTM A 240 type 316
Assembly bolts, nuts and fasteners	Stainless Steel ASTM A 276 type 316
Stem & Coupling	Stainless Steel ASTM A 276 type 316
Yoke	Steel Epoxy painted
Stop Nut, Thrust nut and Lift nut	Gunmetal / Phosphor Bronze

8.8 Trash Rack and Solid Grabbing Unit

8.8.1 Scope of Supply

The scope of supply shall include Trash rack system with all accessories and appurtenances, including, but not limited to:

- Removable J-type Trash racks (MOC:SS 316) which are installed by lowering the same inside guide channels or grooves provided in the trash rack channel so that the trash racks may be readily removed by lifting them through guides.
- Lifting Arrangement by one number electric hoist shall be provided for each manually raked screen and the same shall be permanently attached to screen.
- Rakes for manual cleaning after bringing them on cleaning area.
- Solid Grabbing Unit shall be provided for lifting large volume of solids from the Coarse Screen channel of TSPS/ISPS.
- Electric Hoist and Solid Grabbing unit shall be accommodated adjacently with the I girder arrangement.

8.8.2 General

One trash rack will be installed before the mechanically operated screen, with one working. The structural arrangement of racks generally consists of equally spaced trash rack vertical bars supported on horizontal members connected to end vertical members, which sit in the grooves of guide rail. The trash rack will have J-type structure at the lower end for support and for collection of screened material which

will extend for minimum 600 mm from vertical bars. Hook will be provided at the upper end for lifting of the Trash Rack by Hoist. The minimum thickness of the bars will be 10 mm, width 50 mm it should preferably be fabricated from flats with rounded edges. A platform at suitable/finished ground level shall be provided to manually clean the trash rack by raking and by water jetting arrangements for the collection of screenings in a portable screening container.

All the screens shall be provided with 2 sets of SS 304 cleaning rakes with appropriate grip handle.

8.8.3 Aperture Size

The screen apertures shall be sized to capture particles of 60 mm and above in size. The clear spacing between the bars will be 60 mm.

8.8.4 Inclination of Trash Racks

Racks will be installed on guide rails, which will be kept in a vertical position at 90 degrees.

8.8.5 Velocity through racks

Velocity up to 1.2 m/s at peak flow and 0.6 m/s at average flow on the gross area of racks may be permitted.

8.8.6 Required Downstream Water Level

Contractors should state the maximum and/or minimum allowable water levels downstream of the screen in order to pass the required flow.

8.8.7 The Material of Construction

The material of construction of the trash rack equipment shall be in grade 316L stainless steel.

8.8.8 Manual Raking and Screenings Removal

Suitable arrangement should be made for cleaning the racks manually at regular intervals after removing the trash rack installed in channel through guide rail. The frequency of cleaning of the racks would depend upon the rate of accumulation of trash. Not more than 33 percent of the trash rack area should be allowed to clog the racks at any time. The raked screenings will be collected in portable screenings container.

8.8.9 Structural Requirements

Structural connections in the trash rack should be designed and provided for the failure load of the structural members. All flats should be welded to the intermediate horizontal members and the top and bottom horizontal members for better resistance to vibrations and to avoid stress concentration at the external edge of the groove. The vertical member of the trash rack should be so arranged as to apply the load near the inner part of the rack guide. The guides of the trash racks should be so proportioned that the side members get lateral support from guides after deflection to take up the clearance in the slots.

8.8.10 Access

Safe access shall be provided to all trash racks when hoisted to allow for cleaning, inspection and maintenance activities.

8.8.11 Corrosion Resistance

All metal parts of the screen equipment that are in contact with the sewage shall be constructed of a suitable grade of corrosion resistant stainless steel 316.

8.8.12 Working Stress and Design

The design of all parts shall ensure that under the most onerous of conditions they will not be damaged or corroded.

Any joint that will need to be dismantled during maintenance shall be made by anti-corrosion type fasteners.

All spare parts shall be fully interchangeable with the original part. If the spare part is unavailable due to cease of production, the Contractor shall give notice to the Employer in writing, detailing the options available to the Contractor.

All parts shall be designed to minimize the risk of fire and consequential damage. All parts shall be designed to prevent the ingress of vermin, dust and dirt. All electrically live or moving parts shall be adequately guarded to prevent accidental contact.

8.8.13 Screen solid Grabber Mechanism:

General:

The Grabber Mechanism consists of an overhead monorail system, a travelling trolley, and a grab unit.

The overhead monorail will be formed from minimum 12 mm thick single plate to the required section. This provides a track for the drive and support wheels fitted to the top of the travelling trolley.

The single overhead track will be supported on hollow steel columns and will extend over the width of the bar screen and dump areas.

The trolley unit contains the hoisting unit for the grab and the hydraulic power pack for the operation of the hydraulic cylinder on the grab itself. It is traversed by a geared motor unit mounted on top of the trolley at one end. Polyurethane coated wheels fitted directly to the gearbox output shaft, run on the inside of the monorail sections. A second pair of free running support wheels keeps the trolley parallel with the track.

Power to the trolley will be supplied by a trailing cable which contains both power and control leads and is supported on cable carriages also running in the monorail sections.

The grab unit consists of a series of fingers which are opened or closed by a hydraulic ram. The hydraulic hoses, carrying power to the ram from the power pack in the trolley, are wound on one spring tensioned drum which operate in sequence with the hoisting drums for the grab support ropes. The grab is laterally held in the upper position by spring loaded swing restrictor plates.

The trolley movement and hoisting speed shall be

Hoist Speed:	10 m/min (Minimum)
Traversing Speed:	20 m/min (Minimum)
Grab Opening Closing:	Based on Vendor recommendations
Maximum Solid Load:	1000 Kg S.W.L
Grab Opening/closing time:	Based on Hydraulic power pack movement and actuation.

In operation, the trolley and grab with the fingers open, moves out along the monorail until it is in the first raking position. Here a proximity switch on the trolley senses a position plate on the monorail, the trolley stops and the grab is lowered.

As the grab descends, the downstream fingers engage with the screen bars and top bars on the grab push any accumulated debris to the screen invert. At the invert, the grab stops and the fingers are closed by the hydraulic ram. The grab is then raised, together with any collected debris.

When the grab reaches its top position, the trolley is traversed back to the selected dump position where the fingers are opened, and the debris is deposited. The trolley and grab then return to the next raking position. The number of raking positions is dependent on the overall width and design of the screen. Each raking position is controlled by a proximity plate on the monorail and the position selected is determined, in automatic mode, by a Programme Logic Controller (PLC). When all positions have been raked, the trolley returns and stops at a pre-determined park position.

If a large amount of debris, or other obstruction prevents the grab reaching the screen invert, slack rope devices on the trolley stop the lowering motion, the fingers are closed, and the grab lifted. The collected load is taken to the dump area and deposited. The trolley then travels to the next raking position and continues its cycle.

The top and bottom hoist limits are determined by a rotating arm limit switch unit driven from the main hoist shaft. In addition to the switches for determining the raking and dump positions, limit switches are fitted to each end of the trolley to prevent it contacting the end of the monorail.

The hoist and slack rope proximity switches are backed up by direct contact mechanical limit switches, as a safety precaution.

The hydraulic power to the grab is supplied by an electrically driven pump directly mounted on a tank in the travelling trolley.

When the grab reaches the screen invert, the downward travel is stopped by the preset limit switch, the hydraulic pump motor starts, and a spool valve directs the oil to close the hydraulic ram.

The electrical controls then continue the sequence until the trolley is in the dump position where the spool valve moves to the open position and the hydraulic pump motor is again started.

As soon as the ram is fully open, the hydraulic pump motor is stopped and the electrical sequence controls are re-activated.

In addition to the pressure and spool valves mentioned above, controlled return flow valves are fitted in the lines to the hydraulic ram and a pressure safety valve, set at 120 bar is fitted to the pump discharge.

A return filter with a renewable element is fitted on the tank cover. The filter element is spring loaded to provide bypass if the element becomes blocked.

A low oil level switch is fitted in the hydraulic oil tank (and also a timer is included in the PLC circuit) to prevent loss of oil in the event of a pipe fracture. A pressure gauge and oil level sight glass are also fitted.

MATERIALS OF CONSTRUCTION

Monorail Track:	Hot Dipped Galvanised Mild Steel/Carbon Steel
Structural Columns:	Hot Dipped Galvanised Mild Steel/Carbon Steel
Maintenance Platform:	Hot Dipped Galvanised Mild Steel/Carbon Steel
Trolley Enclosure:	Stainless Steel Gr.304
Trolley Frame:	Hot Dipped Galvanised Mild Steel/Carbon Steel
Grab:	Hot Dipped Galvanised Mild Steel/Carbon Steel
Hydraulic hose drum:	Hot Dipped Galvanised Mild Steel/Carbon Steel
Stainless Steel Gr.304	
Cable Drums:	Hot Dipped Galvanised Mild Steel/Carbon Steel
Fixings & Fastenings:	Hot Dipped Galvanised Mild Steel/Carbon Steel
	& Stainless Steel 304
Hydraulic Tank:	Mild Steel/Carbon Steel epoxy coated
Hydraulic Oil:	As per vendor recommendations
Hoist Cable:	Stainless Steel Gr. 316
Cable Trolley:	Stainless Steel Gr. 304
Sprockets (If applicable)	Carbon Steel epoxy coated
Chains (If applicable)	Stainless steel Gr. 316

Other fixings such as the structural fixing bolts for the gantry and foundation fixings will be galvanised carbon steel.

Motor and control Operation.

Motors shall be squirrel cage type conforming to IS 12615, IS/IEC 60034, IS 15999. The Drive Motor shall be controlled by a Full Voltage Reversing Motor Contactor mounted on a Back Panel to be mounted in an Enclosure or MCC (Motor Control Center) in the main Panel. Motor shall be used for Hoisting, Traversing and Hydraulic power pack units. The power rating of motor shall be at least 125% of maximum power requirement. The other features of motors shall be as follows:

(i)	Type of duty	:	Intermittent (S4)/ Continuous (S1) based on manufacturer's design
(ii)	Method of Starting	:	DOL (VFD if motor rating is above 10 HP and application required frequent starting)
(iii)	Voltage	:	3 Phase, 415V AC
(iii)	Class of insulation	:	F (Temperature rise limited to class B)
(iv)	Type of enclosure	:	TEFC
(v)	Degree of protection:		IP 55
(vi)	Motor Speed:		1500 rpm

The Control panel shall have IP 55 protection, painted with epoxy paint and it shall be Rust proof and shall be comprising of

- Mushroom head emergency stop.
- Overload relays for motor protection.
- Indicating lamps for the functions.
- MCB/MCCB protection
- Control Transformer
- Earthing terminals
- Provision for suitable PLC circuitry shall be provided in case of connectivity and remote monitoring for the plant SCADA system.

8.9 Mechanical Coarse Bar Screen-TSPS / ISPS

8.9.1 General

(a) The screen shall be installed in raw sewage inlet channel, and the screen shall be of the front raking type. Inclined Bar screen at 75 degree and the minimum bar thickness shall be 16 mm x 20 mm with 50 mm width of the bar.

(b) The screen shall be capable of performing the duties set out in this Specification. All the materials and sub-assemblies used shall be suitable for outdoor application. They shall be constructed to minimize maintenance requirements.

(c) Ideally, any moving parts such as sprocket, bearings, etc. should not be in immersed in sewage. In case immersed, the parts shall be of such materials that require little or no maintenance. All lubricating points shall be conveniently accessible from the deck level.

(d) The screen shall be suitable for discharging 75% of the screened material lifted from the screen into the chute.

(e) The screen shall be designed such that in case of heavy accumulation of solids, the same is to be removed gradually without overloading or damaging the screen bars or mechanism.

8.9.2 Frame work

The framework of the screen shall be of robust construction with intermediate cross-bracing. The lower ends and sides of the frame shall be grouted in concrete. Each screen shall have an independent canopy at the top for weather protection. Framework of screen shall be constructed of Grade 316 stainless steel and cross section with a minimum thickness 6 mm. Various parts fastened by welding or bolting shall be braced as necessary to ensure a rigid structure. The side frames shall be minimum 6 mm formed to a channel profile. The bottom thickness shall be minimum 6 mm. The frame shall have support beams with U or C-profile minimum thickness of 6 mm on the front above the maximum water line. The Screen Frame shall be supplied in one piece, requiring no field assembly. Bars shall be supported from framework.

8.9.3 Screen bar assembly

Screen bar assembly shall be fitted across the screen chamber. Screen shall have a series of vertically oriented bars spanning the inlet channel and spaced as specified. Bars shall be sufficiently rigid to prevent vibrations in stream-wise and lateral modes and to withstand the maximum differential head that will occur with the screen totally blinded. Bars shall have tapered cross section to prevent jamming of screenings between bars. Bars shall have supports only at both ends.

8.9.4 Rake carriage

The design shall be multi rake and the rake carriages shall comprise a stiffened frame work to which is attached replaceable rake tines. Rake carriage shall incorporate suitable devices to enable the rake to ride over any small obstacles wedged in the screen and automatically stop the drive motor in the event of the rake jamming against a large obstruction. There shall be no mechanical damage resulting from obstructions wedged in the screen bars. The rake carriage shall always come to rest in a parked position with the rake above the sewage level. The raking tines shall have the tooth profile precision cut from a single continuous bar of enough thickness and depth to ensure adequate stiffness and strength to cope with the specified duty cycle. The rakes shall run in guides on both sides to ensure engagement and clean the bars from the upstream side of the screen. The rakes shall be fabricated from stainless steel Grade 316L. The rake material, thickness of material, and capacity of the rake are similar to the entire construction. The rake tines shall be suitable to accommodate bulky screenings.

Thickness of rake blade 10mm
Reinforcement profile 6 mm

Rake Side Plates 6mm

The screen shall be cleaned automatically through an adjustable timer. The rake lowered will clear screen bars at the beginning of a cycle and accurately engage with the screen bars at the bottom of the channel. The tine profile and rake motion shall be designed to elevate screenings to the discharge chute at deck level, ensuring they do not wrap around the tines or the stationary bars, and also prevent them from falling back into the sewage flow during the cleaning cycle. The rake shall be suitable for elevating debris encountered at any level. Rake tines shall be replaceable.

Screenings transported to the top of the screen shall be discharged positively by means of a scraper mechanism to the discharge chute leading to a screw conveyor system. A scraper blade made of a combination of synthetic and other material shall be provided on the scraper. The rake tines shall then be retracted, and the unit shall be ready for the next cycle. Drive chains, chain guides, chain sprockets, bearings, and axles shall be fully replaceable without having to remove the screen from the channel.

8.9.5 Rake Lifting Mechanism

Lifting Mechanism Chains shall be roller type chains and made of SS 316L and SS 316 sprocket of high tensile strength and resistance to corrosion. The maximum each chain take-up is 112,000 Newton. Chain Pins shall be a Stainless Steel and hardened.

Chain guide shall be securely fixed to the Screen frame for the full height of travel and shall not protrude into the flow. The type of chain guide, thickness of material and size is an L-Profile, Material Grade 316 Stainless Steel. Upper Bearings shall be of UCF Type or equal; housed bearings are grease-lubricated, mounted the Take-Up Frame assembly. No Bearings shall be submerged in the waste stream.

8.9.6 Inspection Platforms

An inspection platform shall be provided for periodic checking and maintenance of the drive and other critical parts. A ladder with handrails for access to this platform shall be fixed. Suitable hand rails shall be provided for safety on the inspection platform and also at deck level. The platform shall have holes to prevent rain water accumulation.

8.9.7 Dead plate

A SS316L dead plate extending from the top of the bars to the deck level shall be provided to ensure that screenings do not fall back. Dead plate shall be made of minimum 6 mm thick plate. The clearance between the tines and the dead plate shall not exceed 6 mm.

8.9.8 Discharge Chute

A discharge chute shall be of minimum 3mm thick provided for each screen to divert screenings discharged from the screen to a conveyor mechanism. The discharge chute shall be made of SS 316. The discharge chute shall be mounted at an angle of minimum 30 degrees. Panels are positioned on both sides to protect from splashing.

8.9.9 Covers

Covers which are easily removable shall be provided for easy maintenance. Covers shall be constructed of clear impact-resistant Polycarbonate material thickness 6 mm and SS 316 thickness is 2 mm to allow for visual observation during screen operation.

8.9.10 Driving Mechanism

The driving mechanism shall consist of a sturdy reduction gear unit driven through multiple 'V' belts or directly by an electric motor. Motor shall be mounted in such a way that the tension of the 'V' belts can be adjusted. A manually reset torque limiter shall be provided between the motor and gear unit, incorporating a limit switch to cut off the supply to motors in the event of an overload. The drive mechanism for the rakes shall incorporate a solid shaft constructed of SS 316.

8.9.11 Installation

The screen shall be designed for installing to (a) pivot out of the channel, (b) be pulled out of the channel. Non-metallic side flaps seal the screen to the channel walls, or (c) The Screen shall be grouted in a wall recess and/or floor recess.

8.9.12 Gear Reducer

(a) The reducer shall be sized and selected with a minimum service factor of 2.0 times the motor horsepower rating in accordance with applicable American Gear Manufacturer's Association Standards. The reducer shall have a life of 40,000 hours based on the motor horse-power. The reducer shall have an efficiency of not less than 90% based on reducer input.

(b) All gear meshes shall be oil lubricated. All gears shall be provided with an oil reservoir for instant lubrication on starting. The gear reducer housing shall be provided with an oil level indicator and an oil drain with necessary fittings.

(c) The gear reducer shall be of cast iron construction. The reducer housing shall also include suitable lifting lugs and external gear train inspection covers for each gear train. The gears shall be matched for maximum tolerance variation. The gear reducer shall be suitable to reduce the motor asynchronous speed to achieve the required speed of raking.

8.9.13 Control System

(a) The screening operation shall be carried out through adjustable timers which are adjustable at site for 0-60 minutes interval between two operations.

(b) Control system for the conveyor shall be designed to achieve the following:

(i) Conveyor shall be started when any of the rakes starts its upwards travel.

(ii) Conveyor shall be stopped with a time delay (by adjustable timer) after rake is stopped.

(c) Weatherproof, lockable, emergency mushroom headed stop push buttons shall be provided near each motor for screen and screw conveyor, operation of stop push button, and overload prevention for screen and screw conveyor shall be included in the control scheme.

8.9.14 Screw Conveyor with compactor

Technical specifications of Screening Conveyor

The Screening Conveyor shall be Shaft Screw Conveyor and applied for conveying the floating debris to the next facilities. The screening system shall be supplied with a shaft screw conveyor that will be used to convey the screenings to the automatic screenings press and discharge system that compacts, dewaters and discharges the screenings through a chute to the screenings storage system.

Dumping of the screenings to the duty/standby conveyor opening shall be with the automatic deflection plate, which shall be positioned towards the conveyor that is selected from the LCP/SCADA for the duty and automatically towards the standby if the duty conveyor trips. Position of this deflection plate shall be interfaced with PLC.

Screening wash compactor shall be suitable for washing and compacting the floating waste coming out of the duty and standby shaft screw conveyor in case of multiple screens, or directly from the screen in case of single screen installed in municipal waste water pumping station or treatment plant.

Shaft screw conveyor shall be made of stainless steel of grade SS 316 and shall incorporate shaft spirals. Cover plates for shaft screw conveyors shall be provided along the entire conveyor length to contain splatter. Conveyor trough covers shall be made from 5 mm of specified grade of stainless steel single piece formed sheet metal, not greater than 1000 mm in length, attached to the screw conveyor trough using toggle clamps. The cover shall also be of sufficiently tight fit to prevent the conveyed media from leaking out of the conveyors. A minimum 2.5 mm neoprene gasket of 50 durometer shall be applied with an appropriate adhesive to the mating surfaces of the trough covers.

Its structure shall have excellent durability for continuous operation over a long time. It shall be abrasion, corrosion and vibration resistance. It should have a structure that is free from debris material clogging.

The spiral flighting for the shaft screw conveyors shall be designed to convey material without a center shaft. The spiral flights shall be designed to ensure stability, preventing distortion and jumping in the trough while operating at the design speed and capacity. The spiral flighting shall be Stainless steel of grade SS 316.

The shaft conveyor trough liner material shall be an ultra-high molecular weight (UHMW) polyethylene with a minimum thickness of 12 mm. There shall be two colored layers in the liner material to indicate wear. The liner shall extend the full length of the trough, covering the entire semicircular bottom portion of the trough. The liner shall be secured at intervals not to exceed 1000 mm, using specified stainless steel retaining clips of an approved design.

Screening wash compactor shall be made of stainless steel of grade SS 316. The wash compactor will receive the waste through the inlet hopper, and the waste shall be dropped into the conveying zone of the compactor's main body.

Screw and liner shall have rigid thickness for resisting corrosion and abrasion caused during carrying of debris. Its structure shall be designed not to invite biting and clogging. Casing shall be equipped with an inspection port for cleaning convenience. The driving device shall have an overload limiting switch to avoid a broken situation caused by overloading.

The conveying zone shall have perforations at the bottom so that the water coming along with the wet screening is dropped in to the dewatering trough. The dewatering trough will have a set of nozzles positioned upwards so that the screening particles clogging the perforations will be removed by the force of spray water. The construction of the dewatering trough shall be inclined towards the drive end so as to enable the flow of water to the drain hole provided with an elbow connection. The compactor main body shall also have a drain hole with an elbow connection.

In the conveying zone there shall not be any impeller wheel or any other mechanical breaking device. The breaking up of organic matter shall be done solely by water through an assembly of nozzles connected with solenoid valves in a special washing zone between the conveying and the compaction zone. The screening shall move towards the compaction zone by a shafted screw of a constant pitch connected to a drive shaft. This drive shaft shall be connected to the drive unit through axial and radial bearings.

An elephant trunk shape outlet tube shall be connected to the compactor body with a flanged connection. An elbow shall be provided at the flanged connection to carry the washed screening in the reduction tube. The reduction tube shall be divergent to ease the push of the washed screening upward in to the outlet tube. The end of the reduction tube shall have an elbow with a discharge plate/chute to enable the collection of the screenings in bagging units or a container.

The Screening wash compactor shall remove the organic material by washing and compaction thus reducing the volume and weight by 50%.

The main body of Screening wash compactor shall have a material thickness of minimum 3 mm and the bottom of the compactor main body shall be perforated with 5 mm holes.

The screw flights of wash compactor shall have a minimum thickness of 12 mm and at the end of compaction zone, there shall be wear bars of 10 mm thickness bolted to the wash press main body/tube for easy replacement.

The elephant trunk shaped outlet tube shall be diverging to prevent the waste getting clogged. The connection of the outlet tube to the main body shall be flanged type. All the bend fittings (elbows) in the outlet tube shall be long radius design.

Frequency Inverter shall be provided for Forward-reverse-forward motion of the screw and as overload protection device.

The gearbox of screw conveyor and wash compactor shall be hollow shaft, parallel helical gear unit have a minimum service factor of 1.2, oil bath lubricated with oil sealing. The motor shall be of TEFC type with minimum IP 55 protection & Class F insulation and be suitable for operation on 3 phase, 415V and frequency of 50 Hz. The drive shaft must be precisely machined and shall have radial and axial bearings.

The common control panel shall have IP 55 protection, painted with epoxy paint and shall comprise of:

- Mushroom head emergency stop.

- Overload relays for motor protection.
- Circuitry to operate the Screening conveyor and wash compactor with a signal for start command from the screen motor start and a delay-timer-based stop command after the screen motor stops.
- Selector switch to operate the Screening conveyor and wash compactor in Auto, manual and remote mode.
- Provision for suitable PLC circuitry shall be provided in case requirement of connectivity with SCADA system.

The Screw conveyor and wash compactor shall be supplied factory assembled and duly tested at manufacturer's works before dispatch. Upon receipt at site these shall be installed resting on the channel floor and mechanically or chemically anchored on to the platform in a way that there are minimum chances of misalignment.

Material of Construction

Screw	SS 316
Screw trough	SS 316
Screw cover	SS 316
Liner	Ultra-High Molecular Polyethylene (UHMPE)

Accessories

Anchor bolts and nuts	1 set
Special tools	1 set
Flexible joint for inlet and outlet	1 set
Liner (for spare)	1 set

8.9.15 Portable Screenings Container

Portable screenings containers made of galvanized steel shall be provided to store the screenings until time of pick up. Minimum two Screenings Containers shall be provided at the screening chamber. The container shall have capacity of approximate 2.0 cum and shall be of a convenient height to permit the discharge of screenings directly into the container without having to transfer the screenings manually. The containers shall have hinged covers and their design shall permit their being lifted by an overhead hoist or packer truck. The container will have four wheels each of minimum 40 cm diameter, Tyre type. The maximum height of container including wheels shall be 66 cms. The sides shall be constructed of 12-gauge steel. The bottom of the container shall be made of 5 mm plate steel. The containers shall be reinforced with 50 mm x 50 mm x 5 mm angle.

8.9.16 Automatic Jam removal system

The screen shall have automatic electronically controlled Jam removal facility to ensure smooth operation without damaging the main equipment.

8.9.17 Motors

Motors shall be squirrel cage type conforming to IS 325. The Drive Motor shall be controlled by a Full Voltage Reversing Motor Contactor mounted on a Back Panel to be mounted in an Enclosure or MCC (Motor Control Center) in the main Panel. The power rating of motor shall be at least 125% of maximum power requirement. The other features of motors shall be as follows:

(i)	Type of duty	:	Intermittent (S4)/ Continuous (S1) based on manufacturer's design
(ii)	Method of Starting	:	DOL
(iii)	Class of insulation	:	F (Temperature rise limited to class B)
(iii)	Type of enclosure	:	TEFC
(iv)	Degree of protection	:	IP 55

(a) The material of construction of Mechanical Raked Screen shall be as follows :

S. No.	Component	Material
(i)	Screen	Stainless steel SS316L
(ii)	Frame (Side and Bottom Portion)	Stainless steel SS316
(iii)	Raked tines	Stainless steel SS316L
(iv)	Fasteners including Anchor bolts	Stainless Steel : 316
(v)	Screen canopy	Stainless Steel: SS316L
(vi)	Chutes	SS316

8.10 Mechanical Fine Screen-WWTP Inlet

General

The mechanically operated self-cleaning fine screening equipment used to collect the fine sized floating solid from travelling in the screen channels before entering to Grit chamber.

Working Principle

The Raw sewage entering the fine screen channel which contains the solids flowing with the sewage while gets retained on the face of the perforated panels of screen, the water passes through. The Screens comprise of screen frame of rugged construction, Screen elements, discharge chute, set of high-pressure nozzles, a pair of chain and sprockets and high efficiency drive unit. As the endless perforated band of screen elements escalates upward, they carry the deposited waste along with it till the waste reaches to the top of screen. At the turning point where the screen element is about to start its downward journey, solid are dislodged from the filer elements by a series of high-pressure water jets nozzles. The solid will fall on to the in-built chute. From the chute the waste can either be collected into a Screw conveyor for separation of waste and wash water and for further disposal. Screen shall be adopted with cleaning mechanism either brushes with motor drive or water spray bar mechanism.

These fine Screen operates by means of level and clogged condition as detected by a level sensor indication in the screen channel,

(i)The screen shall start when raw sewage level reaches maximum water level, screen will operate till water level achieves minimum water level.

(ii) The screen will operate once clogging indication is detected by level sensor through by means of PLC unit of the screens.

8.10.1 Construction features:

A. Frame work

The framework of the screen shall be of robust construction with intermediate cross bracing. The lower ends and sides of the frame shall be grouted or anchored in channel. Each screen shall have an independent canopy at the top for weather protection. Framework of screen shall be constructed of Grade 316 stainless steel and cross section with a minimum thickness 5 mm. Various parts fastened by welding or bolting shall be braced as necessary to insure a rigid structure. The side frames shall be minimum 5 mm formed to a channel profile. The bottom thickness shall be minimum 5 mm. The frame shall have support beams with U or C-profile minimum thickness of 5 mm on the front above the maximum water line. The Screen Frame shall be supplied in one piece, requiring no field assembly. Mesh / Perforated punched plate hole shall be supported from framework.

B. Screen Assembly

The screen shall be provided with a spray nozzles bar or rotating brush (as per design). The screen panels are made of step-type perforated plates covering the entire width of the screen field and are linked to a continuous chain and sprockets forming an endless band.

Step type perforated plate profile can carry large sized solids and avoids formation of clogging. Use of high-pressure nozzle spray system. Primary system above discharge level ejecting entrapped screenings and secondary wash system bringing any remaining residue through drainpipe back in to upstream of the channel. Heavy duty sprockets and chains made of stainless steel and chain pin made of hardened stainless-steel material of special grade. Special grade ceramic bushes with self-lubricating type shall be provided in lower sprockets to ensure very long operative life. Self carrying design its own weight is sufficient to keep the screen securely in position.

The mesh/Perforated punched plate is a combination of bar/ hole along with hook like profile or step type L- profile for carrying the screening, everything connected and assembled through interlocks of SS316L material, to avoid too much head loss through the mesh is optimized.

Screen frames are heavy-duty duty made in SS316L and 5 mm thickness, horizontal tubular pipes are mounted inside frame and assembled properly.

The cleaning brush will be located in solid discharge, will be circular, and Brush hair shall be made of high-quality material with UV and chemical-resistant bristles and Neoprene or Polyurethane blades, cleaning system are activated by helicoidally gearbox with direct transmission, brush will be working always when screen is in working, alternatively a spray nozzle bars can also be given for cleaning of perforated panel on the discharge of screen in place of rotating brush.

C. Inspection Platforms

An inspection platform shall be provided for periodic checking and maintenance of the drive and other critical parts. A ladder with handrails for access to this platform shall be fixed. Suitable handrails shall be provided for safety on the inspection platform and also at deck level. The platform shall have holes to prevent rainwater accumulation.

D. Discharge Chute

A discharge chute shall be of minimum 4 mm thick provided for each screen to divert screenings discharged from the screen to a conveyor mechanism. The discharge chute shall be made of SS 316. The discharge chute shall be mounted at an angle of minimum 30 degrees. Panels are positioned on both sides to protect from splashing. Screenings are delivered down an enclosed chute. Two nos. Screening containers (wheeled) of suitable capacity shall be supplied with the screens.

E. Covers

Covers which are easily removable shall be provided for easy maintenance. Covers shall be constructed of clear impact-resistant Polycarbonate material thickness 6 mm and SS 316 thickness is 2 mm to allow for visual observation during screen operation.

F. Driving Mechanism

The driving mechanism shall consist of a sturdy reduction gear unit driven directly by an electric motor. A manually reset torque limiter shall be provided between the motor and gear unit, incorporating a limit switch to cut off the supply to motors in the event of an overload. The drive mechanism for the shall incorporate a solid shaft constructed of SS 316. The drive to the main shaft shall be TEFC weatherproof IP55 motor fitted with an anti-condensation heater. The motor shall be flanged to a shaft-mounted gear unit giving the final output speed. This shall produce a linear speed for the screen panels of about 3 m/min. The drive shall be protected from mechanical overload by an electrical current sensing device in the screen control panel. Suitable conveyer arrangement shall be provided to transfer the screenings to the nearest container/trailer. A spray system shall be provided to backwash the screen panels and to help in cleaning the screenings. Water / treated sewage shall be used for back wash purpose.

8.10.2 Installation

The screen shall be designed for installation to either (a) pivot out of the channel, (b) be pulled out of the channel. Non-metallic side flaps seal the screen to the channel walls, or (c) The Screen shall be

grouted in a wall recess and/or floor recess. Minimum 600 mm access clearances between the screens shall be provided. And screens shall be designed in such way that minimal tools shall be used removal of screen Panels and covers during maintenance. The contractor shall maintain minimum spares parts such as brushes, nozzles, chain links and sensors.

8.10.3 Surface Finishing:

Stainless steel components shall be fabrication and then pickled and passivated on all surfaces to remove any ferrous contamination taking place during the process of welding, cutting, machining, and handling.

8.10.4 Gear Reducer

(a) The reducer shall be sized and selected with a minimum service factor of 2.0 times the motor nameplate horsepower rating in accordance with applicable American Gear Manufacturer's Association Standards. The reducer shall have a life of 40,000 hours based on the motor name plate horse-power. The reducer shall have an efficiency of not less than 90% based on reducer input.

(b) All gear meshes shall be oil lubricated. All gears shall be provided with an oil reservoir for instant lubrication on starting. The gear reducer housing shall be provided with an oil level indicator and oil drain with necessary fittings.

(c) The gear reducer shall be of cast iron construction. The reducer housing shall also include suitable lifting lugs and external gear train inspection covers for each gear train. The gears shall be matched for maximum tolerance variation. The gear reducer shall be suitable to reduce the motor asynchronous speed to achieve the required speed of raking.

8.10.5 Control System

(a) The screening operation shall be carried out through adjustable timers which are adjustable at site for 0-60 minutes for interval between the two operations (Screens & Conveyor).

(b) Control system for the conveyor shall be designed to achieve the following:

  (i) Conveyor shall be started when any of the rakes starts its upwards travel.

  (ii) Conveyor shall be stopped with a time delay (by adjustable timer) after rake is stopped.

(c) Weatherproof, lockable, emergency mushroom headed stop push buttons shall be provided near each motor for screen and screw conveyor Operation of stop push button, and overload prevention for screen and screw conveyor shall be included in the control scheme.

(d) The panel should be made of Stainless steel SS316 with IP-55 protection and comprise of Mushroom Head Emergency stop switch, Overload relays for motor protection, MCB's, HRC Fuses, Control circuitry to operate the screen with Differential radar type level sensors Selector Switch to operate the screen on clogging mode and this entire screen & conveyer system shall be operated in fully automatic modes of operation. Screen cleaning trigger shall be provided for every minimum 30 minutes even if no clog is detected to prevent biofouling. Also, the Alarms (Trip, Torque, motor overload & high, Low-water Level sensing etc..) as applicable shall be populated as Alarms to the Operator for further intervention ir-respective of any mode of operation.

(e) Variable Frequency Drive should be provided with panel.

Technical particular and MOC are listed in the table below:

Si.no.	Technical Description	Data
1.	Perforation size of screen Step/ Mesh or Plate	4 mm (maximum)
2.	Screen Mesh or Plate thickness	4 mm
3.	Top, Bottom & Side Plates	Minimum 5 mm thick
4.	Discharge chute	Minimum 4 mm thick
5.	Angle of Inclination	65 to 75 degree
	Material of construction	
a.	Screen Filter step/Mesh or Plate	Stainless Steel ASTM A 240, Grade 316L
b.	Screen Frame (Top, Bottom, Adjacent Sides and Dead Plates)	Stainless Steel ASTM A 240, Grade 316
c.	Drive Chain & Sprocket	Stainless Steel ASTM A 240, Grade 316L/ Duplex Stainless Steel SAF 2205
d.	Drive Shaft	Stainless Steel ASTM A 276, Grade 316
e.	All Fasteners and Anchor Bolts	Stainless Steel, Grade 316
f.	Discharge chute	Stainless Steel ASTM A 240, Grade 316
g.	Spray bars & jet nozzles	Stainless Steel ASTM A 240, Grade 316L
h.	Dewatering tube	Stainless Steel ASTM A 240, Grade 316L

8.10.6 Controls And Instrumentation

A. General

i) Fine Screens

Sewage flow shall enter the inlet common channel of fine screens. The high-level in this channel shall initiate a screen cleaning cycle, and both the "Low" and "high-high" level shall generate an alarm.

The fine screens shall be operable manually by using Auto / Manual position control switch from a local control panel located adjacent to the equipment or remotely from the WwTP SCADA / HMI. Remote operation shall be operator selectable as manual or auto. In auto mode, operation of the screen rake mechanism shall be controlled by level differential with a timer override. Radar Type Level Sensors shall be installed both upstream and downstream of the screens. When the upstream minus downstream level differential reaches an operator specified maximum, a screen cleaning cycle shall be initiated. Alternatively, the operator may also specify a maximum interval between cleaning cycles (as Timer Setpoints configurable). If this interval elapses without cleaning, a cleaning cycle shall be initiated regardless of level differential. The speed of Screen drives shall be synchronized automatically by using VFDs during any clog situation to retain back to the original position with minimum number of iterations otherwise those drives shall be tripped automatically for further manual interventions. The upstream and downstream levels shall be continuously monitored by differential level measuring systems.

Alarms/faults and status shall be monitored/logged, and control commands shall be generated in accordance with the Engineer-approved I/O list (As per Typical Drive Control Philosophy table in Part-13).

ii) Screening Conveyer

The screening conveyer shall operate in Auto mode in linkage with the Fine screens. The screening conveyer can be operated manually by the operator at a local control panel located adjacent to the equipment for trouble shooting or maintenance, or at the WwTP SCADA / HMI.

Alarms/faults and status shall be monitored/logged, and control commands shall be generated in accordance with the Engineer-approved I/O list (As per Typical Drive Control Philosophy table in Part-13).

The entre screen & conveyer system shall be operated in fully automatic operational requirement. The conveyor drive trips when all screen drives under trip mode otherwise conveyor drive operation shall be continuously in Run mode. The Screen Control Panel embedded with internal wiring stand-alone PLC & 10 inches panel mounted touch screen HMI system which includes Potential free contacts / Terminal Blocks / Selector Position Control switches (Manual / Auto) and also entire Screen PLC / HMI data (Feedbacks & Command signals including Alarms) shall be interfaced with WwTP PLC / SCADA system by using hard wired communication system (Compatible protocol in line with WwTP PLC / SCADA System) for the purpose of continuous monitoring and control operations. For more details,

please refer SCADA CONTROL SYTEM ARCHITECTURE DRAWING in Volume-4 of the tender document.

The control system shall be provided by the screen supplier.

B. LOCAL CONTROLS (PER SCREEN)

1. One (1) National Electrical Manufacturers Association (NEMA 7, 4-hole, Class 1 Division 1) approved Cast Aluminium local control station.

C. CONTROL PANEL

1. Manufacturer shall provide control panel with a lockable NEMA 4X corrosion-resistant stainless-steel enclosure for free standing. Contractor shall install the control panel and provide wiring.
2. Control panel shall contain all power and control devices necessary for the proper function of the screen and shall include the following:
   a. 600-Volt rated main circuit breaker disconnect with lockable handle
   b. 480 – 120 Volt control power transformer
   c. VFD and Circuit Breaker Branch Circuit Protection for main screen drive motor
   d. VFD and Circuit Breaker Branch Circuit Protection for screen cleaning brush motor
   e. Control Panel ON-OFF selector switch
   f. MANUAL-OFF-AUTO selector switch for the operation of the screen drive
   g. 3-pole reversing contactors with screw clamp terminals, motor protection relays and all other necessary equipment for screen motor and brush motor protection
   h. “Screen Drive On” indication
   i. “Brush Drive On” Indication
   j. “Wash Water On” Indication
   k. “Screen Motor Fault” indication
   l. “High Water Level” indication
   m. “Control Power” indication
   n. Alarm silence and reset push buttons
   o. Spare contact for remote indication of “Screen Motor Fault” alarm
   p. Spare contact for remote indication of “High Water Level” alarm
   q. Spare contact for remote indication of “Control Power Failure” alarm
   r. Control relays, wiring and circuitry required to implement the control logic
   s. Programmable controller (PLC) & Operator Interface (i.e. Panel mounted 10 inches touch screen HMI) makes shall be followed as per approved make list of PLC / Instrumentation in Part-13.
   t. “Emergency-Stop Operated: pop-up with Alarm Indication

8.10.7 Screw Conveyor with compactor

(a) Technical specifications of Screening Conveyor

The Screening Conveyor shall be Shaft Screw Conveyor and applied for conveying the floating debris to the next facilities. The screening system shall be supplied with a shaft screw conveyor that will be used to convey the screenings to the automatic screenings press and discharge system that compacts, dewaters and discharges the screenings through a chute to the screenings storage system.

Dumping of the screenings on to the duty/standby conveyor opening shall be with the automatic deflection plate, which shall be positioned towards the conveyor which is selected from the LCP/SCADA for the duty and automatically towards the standby if duty conveyor trips. Position of this deflection plate shall be interfaced with PLC.

Screening wash compactor shall be suitable for washing and compacting the floating waste coming out of the duty and standby shaft screw conveyor in case of multiple screens, or directly from the screen in case of single screen installed in municipal waste water pumping station or treatment plant.

Shaft screw conveyor shall be made of stainless steel of grade SS 316 and shall incorporate shaft spirals. Cover plates for shaft screw conveyors shall be provided along the entire conveyor length to contain splatter. Conveyor trough covers shall be made from 5 mm of specified grade of stainless steel single piece formed sheet metal, not greater than 1000 mm in length, attached to the screw conveyor trough using toggle clamps. The cover shall also be of sufficiently tight fit to prevent the conveyed media from leaking out of the conveyors. A minimum 2.5 mm neoprene gasket of 50 durometer shall be applied with an appropriate adhesive to the mating surfaces of the trough covers.

Its structure shall have excellent durability to continuous running for long time. It shall be well taken into account of abrasion resistance, corrosion and vibration resistance. It should have a structure which is free from debris material clogging.

The spiral flighting for the shaft less screw conveyors shall be designed to convey material without a center shaft. The spiral flights shall be designed with stability to prevent distortion and jumping in the trough while operating at design speed and design capacity. The spiral flighting shall be Stainless steel of grade SS 316.

Shaft conveyor trough liner material shall be an ultra-high molecular (UHMW) polyethylene with a minimum 12 mm thickness. There shall be two colored layers in the liner material to indicate wear. The liner shall extend the full length of the trough, covering the entire semicircular bottom portion of the trough. The liner shall be secured at intervals not to exceed 1000 mm, using specified stainless steel retaining clips of an approved design.

Screening wash compactor shall be made of stainless steel of grade SS 316. The wash compactor will receive the waste through inlet hopper and the waste shall get dropped in to the conveying zone of the compactor main body.

Screw and liner shall have rigid thickness for resisting corrosion and abrasion caused during carrying of debris. Its structure shall be designed not to invite biting and clogging. Casing shall be equipped with inspection port to the necessity as well as for cleaning convenience. Driving device shall have overload limiting switch for avoiding broken situation caused by overloading.

The conveying zone shall have perforations at the bottom so that the water coming along with the wet screening is dropped into the dewatering trough. The dewatering trough will have a set of nozzles positioned upwards so that the screening particles chocking the perforations will be removed by the force of spray water. The construction of the dewatering trough shall be inclined towards the drive end so as to enable the flow of water to the drain hole provided with an elbow connection. The compactor main body shall also have a drain hole with an elbow connection.

In the conveying zone there shall not be any impeller wheel or any other mechanical breaking device. The breaking up of organic matter shall be done solely by water through an assembly of nozzles connected with solenoid valves in a special washing zone between the conveying and the compaction zone. The screening shall move towards the compaction zone by a shafted screw of a constant pitch connected to a drive shaft. This drive shaft shall be connected to the drive unit through axial and radial bearings. An electronic device shall operate the drive unit of the spiral in a forward reverse mode, separated by a stand still period. The time of forward and reverse operation as well as the stand still time shall be freely adjustable.

The non-drive end of the screw shall have the flight of reduced pitch in the compaction zone. For achieving better strength at non-drive end, the screw must be supported by wear bars connected to the wash press main body and reinforced with double flights of defined pitch.

An elephant trunk shape outlet tube shall be connected to the compactor body with a flanged connection. An elbow shall be provided at the flanged connection to carry the washed screening in the reduction tube. The reduction tube shall be divergent to ease the push of the washed screening upward into the outlet tube. The end of the reduction tube shall have an elbow with discharge plate/chute to enable the collection of the screenings in bagging units or a container.

The Screening wash compactor shall remove the organic material by washing and compaction thus reducing the volume and weight by 50%.

The main body of Screening wash compactor shall have a material thickness of minimum 3 mm and the bottom of the compactor main body shall be perforated with 5 mm holes.

The screw flights of wash compactor shall have a minimum thickness of 10 mm and at the end of compaction zone, there shall be wear bars of 10 mm thickness bolted to the wash press main body/tube for easy replacement.

The elephant trunk shaped outlet tube shall be diverging to prevent the waste getting clogged. The connection of the outlet tube to the main body shall be flanged type. All the bend fittings (elbows) in the outlet tube shall be long radius design.

Frequency Inverter shall be provided for Forward-reverse-forward motion of the screw and as overload protection device.

The gearbox of screw conveyor and wash compactor shall be hollow shaft, parallel helical gear unit have a minimum service factor of 1.2, oil bath lubricated with oil sealing. The motor shall be of TEFC type with minimum IP 55 protection & Class F insulation and be suitable for operation on 3 phase, 415V and frequency of 50 Hz. The drive shaft must be precisely machined and shall have radial and axial bearings.

The common control panel shall have IP 55 protection, painted with epoxy paint and shall be comprising of

- Mushroom head emergency stop.
- Overload relays for motor protection.
- Circuitry to operate the Screening conveyor and wash compactor with signal for start command from screen motor start and delay-timer based stop command after the screen motor stops.
- Selector switch to operate the Screening conveyor and wash compactor in Auto, manual and remote mode.
- Provision for suitable PLC circuitry shall be provided in case requirement of connectivity with SCADA system.

The Screw conveyor and wash compactor shall be supplied factory assembled and duly tested at manufacturer's works before dispatch. Upon receipt at site these shall be installed resting on the channel floor and mechanically or chemically anchored on to the platform in a way that there are minimum chances of misalignment.

Material of Construction

Screw	SS 316
Screw trough	SS 316
Screw cover	SS 316
Liner	Ultra-High Molecular Polyethylene (UHMPE)

Accessories

Anchor bolts and nuts	1 set
Special tools	1 set
Flexible joint for inlet and outlet	1 set
Liner (for spare)	1 set

8.10.8 Portable Screenings Container

Portable screenings containers made of galvanized steel shall be provided to store the screenings until time of pick up. Minimum two Screenings Containers shall be provided at the screening chamber. The container shall have capacity of approximate 2.0 cum. and shall be of a convenient height to permit the discharge of screenings directly into the container without having to transfer the screenings manually. The containers shall have hinged covers and their design shall permit their being lifted by an overhead hoist or packer truck. The container will have four wheels each of minimum 40 cm diameter, Tyre type. The maximum height of container including wheels shall be 66 cms. The sides shall be constructed of 12-gauge steel. The bottom of container shall be made of 5 mm plate steel. The containers shall be reinforced with 50 mm x 50 mm x 5 mm angle.

8.11 Manual Medium Bar Screen for WWTP

(a) The screen shall be installed in inlet bypass channel to grit chamber.

(b) The aperture size of the screen shall be 10 mm and 50 angle of inclination.

(c) The screen shall be fabricated out of SS316 flats and fixing bolts shall be of stainless steel.

(d) The rectangular trash screens shall comprise SS 316, 10 mm thick and 50 mm wide in section.

(e) The screen shall be rigidly fixed to the frame.

(f) All the bypass screens shall be provided with 2 sets of SS 304 cleaning rakes with appropriate grip handle.

8.12 Manually Operated Travelling Crane

8.12.1 Crane

(a) The crane shall be manually operated for return activated sludge pumping station.

(b) The capacity of crane shall be as per the equipment list in particular mechanical requirement and of class II.

(c) The crane bridge shall consist of a single bridge girder carrying two wheels at each end of the span. Steel used shall be tested quality steel conforming to IS 2062.

(d) The long travel bridge wheels shall be rim toughened; heat treated galvanized carbon steel or low alloy steel or C.I. They shall be double flanged type. The wheels shall have antifriction ball/roller bearings. The wheels shall be machined on their treads to match the runway rail section. The bridge shall have a geared shaft and pulley connecting to opposite wheels of the span, to achieve the long travel motion of the bridge, by means of a chain. The runway rails of adequate strength and rigidity, rail clamps and other accessories for mounting the rails and suitable end stops for the bridge shall be supplied by the Contractor.

8.12.2 Trolley and Chain Pulley Block

(a) The chain pulley block shall be operated on the lower flange of the bridge girder.

(b) The load chain shall be made of alloy steel as per IS: 3109. It shall be heat treated to give ductility and toughness so that it will stretch before breaking. It shall be of welded construction with a factor of safety not less than 5.

(c) The hand chains, SS 316, for the hoisting and traverse mechanism shall hang well clear of the hook and both the chains shall be on the same side. The hand chain wheel shall be made from pressed sheet steel and shall be provided with roller type guarding to prevent snagging and fouling of the chain.

(d) All the gearing shall be totally encased. Proper lubricating arrangements shall be provided for bearings and pinions. Gears shall be cut from forged steel blanks. Pinions shall be of heat treated alloy steel. Gears shall be as per BS 436/IS: 4460.

(e) The trolley track wheels shall be rim toughened, heat treated carbon steel or alloy steel and shall be single flanged and shall have antifriction ball bearings. The wheels shall be machined on their treads to match the flanges of the track joints.

(f) The travelling trolley frame shall be made of rolled steel conforming to IS: 2062. The side plates of trolley frame shall extend beyond wheel flanges, thus providing bumper protection for the wheels. The two side plates shall be connected by means of an equalizing pin.

(g) Axles and shafts shall be made of carbon steel and shall be accurately machined and properly supported.

(h) The lifting hooks shall be forged, heat treated alloy or carbon steel of rugged construction. They shall be of single hook type provided with a standard depress type safety latch. They shall swivel and operate on antifriction bearings with hardened races. Locks to prevent hooks from swiveling shall be provided. Hook shall be as per BS:2903/IS:3815

(i) The brake for the lifting gear shall be automatic and always in action. It shall be of screw and friction disc type self-actuating load pressure brake. Brakes shall offer no resistance during hoisting.

8.13 Electrically Operated Hoists

(a) Electric hoists shall be complete with hoisting motor, wire rope drum, wire rope, hook, necessary gearing, sheaves, electromagnetic brake for hoisting motion, weather & dust-proof push button station, contractor panel, all wiring, limit switches, etc.

(b) Electric hoists shall conform to IS: 3938 and shall be suitable for outdoor application. All the parts of the hoist shall be designed to withstand surrounding atmospheric conditions without any deterioration.

(c) Rope drums shall be either cast or welded to sustain concentrated loads resulting from rope pull. Drums shall be machine grooved right and left with grooves of a proper shape for the rope used.

(d) Gears shall be cut from solid cast or forged steel blanks or shall be of stress-relieved welded steel construction or built-up from steel billets and welded together to form a one piece gear section. Hoist ropes shall be extra flexible, improved plough steel rope with a well lubricated hemp core and having six strands of 36 wires per strand with minimum ultimate tensile strength of 1.6 x 106 KN / Sqm.

(e) Hooks shall be solid, forged, heat treated alloy or carbon steel of rugged construction of the single hook type and provided with a standard depress type safety latch.

(f) Hoisting motor shall be equipped with electrically released, spring set, friction shoe type brakes having torque capable of holding 125% of the full rated hook load. Brake shall apply when either the motor controller or the main power switch is in 'OFF' position or in the event of power failure.

(g) Drive motors shall be designed for frequent reversal, braking and acceleration and shall be as per IS: 325. Pendant control switch, controllers and resistors, controls, electrical protective devices, cables and conductors, earthing guards etc. shall be as per IS:3938. Limit switches shall be provided for over-hoisting and over-lowering.

(h) The electric hoists shall be of Class II duty.

(i) 25% overload test, speed tests, limit switch tests and brake test shall be conducted for the hoist and trolley at manufacturer's works.

(j) Minimum Two sets. of sufficient slings, ropes, shackles, lifting beams, etc, shall be supplied to handle all items of plant covered by the crane. They shall be labelled or marked with the Safe Working Load (SWL) and the purpose for which they are intended.

8.14 Hand Operated Hoists and Trolleys

(a) Manual hoists shall be complete with hand-chain, trolley, pulley block, hook, hand and load chains, brake and other accessories. They shall comply with the latest applicable standards, regulations and safety codes in the locality where equipment will be installed.

(b) Each hoist shall be operated on a monorail (I-Beam). The factor of safety shall not be less than 5. The load chain may be heat-treated to give ductility, toughness and conforming to I.S. 3109/B.S.1663/B.S.3114. The load wheel is to be made from heavy duty malleable castings. The hand chain is to Conform with B.S. 6405 and hand chain wheel may be made from pressed sheet steel with roller type guarding. Gears shall be cut from solid cast or forged steel blanks or shall be stress – relieved welded steel construction.

(c) Pinions shall be of forged carbon or heat treated alloy steel. Strength, Quality of Steel, heat treatment, face, pitch of teeth and design shall confirm to BS-436, BS-545 and BS-721. Spur and helical gears must comply with B.S. 436 and worm with BS 721. Bearing must be ball and roller type conforming to I.S. 2513/B.S., 2525-32.

(d) Proper lubricating arrangements are to be provided for bearings and pinions. The brake for the lifting gear shall be automatic and always in action.

(e) The proof testing of each chain pulley block is to be carried out as per latest applicable standards. The safe working load is to be marked in such way that is clearly visible from the operating level.

(f) Minimum Two sets. of sufficient slings, ropes, shackles, lifting beams, etc shall be supplied to handle all items of plant covered by the crane. They shall be labelled or marked with the Safe Working Load (SWL) and the purpose for which they are intended.

8.15 Electrically Operated Overhead Travelling Crane

(a) The crane shall be electrically operated, bridge type complete with all accessories including down shop conductor, crane rails and fixtures, and shall conform to BS 2573, IS:3177 or relevant internationally approved standards.

(b) The crane bridge shall consist of bridge girders on which a wheeled trolley is to run. The bridge trucks and trolley frames shall be fabricated from structural steel. Access walkway with safe hand railing as is required along the full span length of the bridge girder. Steel shall be tested quality conforming to ASTM A36 except that, plates more than 20 mm thick shall conform to IS:2062, BS:4360 or relevant internationally approved standards.

(c) The bridge shall be designed to carry safely the loads specified in IS: 807, BS: 2573 or relevant internationally approved standards. All anti-friction bearings for bridge and trolley track wheels, gear boxes and bottom sheaves on hook shall be lubricated manually by hand operated grease pump through respective grease nipples.

(d) Wheel base and structural frame of the wheel mounting of the end carriages shall be designed so as to ensure that the crane remains square and prevent skewness. Bridge and trolley track wheels shall be of forged steel and shall be double flanged type. The wheel diameter and rail sizes shall be suitable for the wheel loads.

(e) The crane rails shall be manufactured from wear resistant austenitic manganese steel. Mountings of the wheels shall be designed to facilitate easy removal for maintenance. Walkways shall be at least 500 mm clear inside width with a 6 mm thick non-skid steel plate surface. Steel rail stops to prevent rails from creeping and trolley from running off the bridge shall be abutted against ends of rails and welded to the girders. Bridge and trolley stops to match the wheel radius shall be provided before the buffer stops.

(f) All exposed couplings, shafts, gear, wheels, pinions and chain drives etc. shall be safely encased and guarded completely to prevent any hazard to persons working around. All bearings and gears shall have a design life of 100000 hours. Electro-magnetic and hydraulic thrust or brake shall be provided for the main hoist. One electro-magnetic brake shall be provided for each of the cross travel and long travel motions.

(g) Hook shall be solid forged, heat treated alloy or carbon steel suitable for the duty service. They shall have swivels and operate on ball thrust bearings with hardened races. The lifting hooks shall comply with the requirements of IS 8610 or BS: 2903 / BS: 3017 or relevant internationally approved standards and shall have a safety latch to prevent rope coming off the hook.

(h) Hoist rope shall be extra flexible, improved plough galvanized steel rope with well lubricated hemp core and having six strands of 36 wires per stand with minimum ultimate tensile strength of 1.6 X 10^6 kN/m2 of Right Hand Ordinary (RHO) lay construction. The

ropes shall have a 6:1 safety factor on the specified safe working load, and shall conform to IS: 2266. Rope drums shall be grooved and shall be either cast iron or cast steel of or welded steel conforming to IS:3177, BS:466 or relevant internationally approved standards.

(i) Gears shall be cut from solid cast or forged steel blanks or shall be stress relieved welded steel construction. Pinions shall be of forged carbon or heat treated alloy steel. Strength, quality of steel, heat treatment, face, pitch of teeth and design shall conform to BS:436, IS:4460 and BS: 721 or relevant internationally approved standards.

(j) Name Plate showing the capacity, year of manufacture and rated capacity of hoist in figures not less than 150 mm height shall be placed on each side of the crane girder.

(k) The maximum deflection under full load shall not exceed 1/900 of the span (as per IS: 3177).

(l) All accessory and auxiliary electrical equipment including drive motors, electrically operated brakes, controllers, resistors, conductors, insulators, current collectors, pendant push button station, protective devices, operating devices, cables, conduits, etc. necessary for the safe and satisfactory operation of the crane shall be provided. (Power to the crane shall be provided by down shop conductors manufactured from high conductivity hard drawn copper. Conductors shall be completely shrouded such that they have no exposed current carrying surfaces.

Pendant type push button station shall be sheet steel enclosed and shall comprise the following push buttons and indicating lamps:

(i) `Start' and `Stop'.
(ii) Long travel - `Right' and `Left'.
(iii) Cross travel - `To' and `Fro'.
(iv) Hook - `Hoist' and `Lower'.
(v) Red indicating lamp for supply `ON' indication.

(m) Pendant type push button shall be supported independently of the electrical cable and shall be earthed separately, independent of the suspension. Automatic reset type of limit switches shall be provided to prevent over travel for each of the following:

(i) For `UP' and `Down' motions of the hook.
(ii) Long travel motion
(iii) Cross travel motion

(n) Crane structures, motor frames and metal cases of all electrical equipment including metal conduit and cable guards shall be earthed. All motors, brakes, limit switches, panels, drum controllers, resistor unit sets shall be provided with two studs for earthing.

(o) The crane, and all slings, ropes, shackles and other lifting equipment supplied shall be tested by the manufacturer at his works. The tests shall be carried out at 125% of Safe Working Load, and Test Certificates shall be supplied.

(p) All motors shall be of the quick reversing type with electric mechanical brakes suitable for the duties specified. All movements shall be electrically powered suitable for operating with the

hook loaded. Facilities shall be provided for the accurate location of the hook by means of `inching' the cross travel and down shop travel motions.

(q) Minimum Two sets. of sufficient slings, ropes, shackles, lifting beams, etc shall be supplied to handle all items of plant covered by the crane. They shall be labelled or marked with the Safe Working Load (SWL) and the purpose for which they are intended.

(r) The Contractor shall include with the cranes all necessary contactors, control cubicles and protection equipment necessary to operate the crane and provide adequate electrical protection against overload, phase and earth fault and fail-safe protection in the event of an interruption in the power supplies. All access ladders and platforms necessary to carry out maintenance and repairs shall be provided and installed by the Contractor.

(s) All electrical equipment shall be fully tropicalised.

(t) Site tests shall be carried out by the Contractor who shall supply the necessary materials for the test load. The test load shall be removed from site by the Contractor after successful tests have been carried out.

8.16 Jib cranes

Fixed Jib Cranes shall be provided for each clarifier in the lowering/removal of equipment/parts to/from the clarifier floor and transferring the same outside the clarifier area. The Jib Crane capacity shall be 1.25 times the maximum weight to be handled in the clarifier or 2.0 Tonnes whichever is maximum.

The lift and reach of the cranes shall be suitable for the clarifier offered. The crane shall be capable of being swivelled by 360°.

All materials used in the construction shall be corrosion resistant. Mild steel used shall be galvanised. Ropes, chains and pulleys shall be of stainless steel construction. Hardware shall be of SS 316.

8.17 Grit Removing Equipment

The Contractor has to evaluate between the two type vortex grit mechanisms as given below, suggest a best efficient system by making Life Cycle Cost (LCC) of the equipment, by considering its merits and demerits.

8.17.1 Vortex Grit Mechanism with Slurry (Turbo) Pump

GENERAL

The Grit Chamber shall operate on the vortex principle. Each Vortex Grit Chamber, complete with all accessories including, but not necessarily limited to: gear motor, gear head, air bell, propeller, drive tube, axial propeller, Grit Removal Pump and auxiliary equipment as specified herein shall be provided.

The grit removal device shall be capable of removing the following at the specified hydraulic peak flow rate, and no decrease in efficiency will be allowed at flows less than this design rate.

- 95% of the grit greater than 150 microns in size.
- 85% of the grit greater than 100 microns.

Organic removal: The final dewatered grit from the classifier / washer shall contain less than 5% putrescible organic matter on dry basis.

System Description:

- The Grit Chamber shall operate on the vortex principle. Each Vortex Grit Chamber, complete with all accessories including, but not necessarily limited to: gear motor, gear head, air bell, propeller, drive tube, axial propeller, Grit Removal Pump and auxiliary equipment as specified herein shall be provided.
- The Vortex Grit removal system shall be installed in concrete basins.
- The grit removal chamber shall have inlet and outlet separated by 270 or 360 degrees of the tank periphery.
- The Grit Chamber shall handle all flows equal to or less than a hydraulic peak flow. The influent flume, transporting the liquid waste to the Grit Chambers, should ensure that grit does not settle in the inlet flume for proper operation of the Grit Chamber.
- The Grit Removal Unit shall have lesser head loss and shall be capable of removing grit from raw waste or process water and depositing the grit in a storage hopper.
- No moving parts subject to wear or stoppage shall be below the water surface.
- An influent baffle or equivalent and inlet Ramp/annulus ring shall be provided to enhance the effect and direct the grit downward to the bottom of the separation chamber as well as enhance chamber flow patterns.
- To minimize the possibility of organic capture, the floor of the grit separation chamber shall be flat/conical/Sloped shaped and opening for grit to pass through to the storage hopper.
- To ensure the efficient transport of the grit and simultaneous lifting and discharge of the organic material, the bottom of the upper chamber covering the storage hopper shall be constructed of structural grade SS316 plate, free from rotation, and shall be flat/conical /Sloping Shaped.
- The grit moving across the bottom of the chamber shall be hydraulically scoured as the propeller blades, moving within 150 mm dia. of the grit, pass over the moving grit and cause hydraulic currents to lift up the organics. The propeller blades shall be designed to provide pumping action inside the chamber.
- To maximize grit removal efficiency, the grit chamber hydraulics shall incorporate a toroidal flow path enhanced by a slow vortex. Grit chambers incorporating the gravity principle will not be acceptable due to the turbulence in the flow, which prevents gravity settling from being effective and due to the extra area needed for settling fine grit.
- The grit shall pass from the removal chamber through an opening in the transition plate and drop into a grit storage hopper.
- Grit pump shall be remote mounted or top mounted grit pump.
- An integral grit pump shall be provided to transport the grit from the storage hopper to the grit classifier / washer and the dewatered grit shall be temporally stored in tiltable trolley.

- To minimize the possibility of clogging, all internal openings in the piping to the grit pumping device as well as the grit pumping device shall be large enough to pass a 80 mm solid size.
- No bends or elbows will be allowed in the piping on the suction side of Grit Pump.
- The Grit Concentrator shall operate on the constant rate vortex principle. Design shall be such that a small volume of water and the grit will discharge at the bottom for final dewatering and ultimate disposal of the grit.
- Grit Screw Classifier / washer shall be with an inlet hopper to receive the mixture of water and grit each from the Grit Concentrators.
- All drives, lubrication and bearings shall be readily accessible from walkways above the operating water level.

Material of Construction:

- All wetted parts shall be in SS316.
- The pump shall be of Ni-Hard/Hi chrome construction, with Ni-Hard impeller, and especially designed for the use of mechanical seals. The shaft shall be solid stainless steel through the mechanical seal, heavy duty bearings and mechanical seal.
- Grit concentrator shall be constructed of Ni-Hard/Hi chrome SS316 with a minimum thickness high wear area, it features a large discharge orifice to minimize clogging.
- Grit Screw Classifier / washer shall be constructed of SS316.

8.17.2 COMPACT Pre-Treatment System (COMBI Unit)

A. Scope of Supply

Combi units are used for pre-treat wastewater before introducing the wastewater treatment plants. They perform fine screening with a Screening conveyor and compactor, and Grit removal with a Grit washing system and grease removal system. All these treatments are performed on a single equipment.

The inflow streams at first passes through a rotary drum screen (with 4 mm spacing) installed in the first chamber which removes all the floating and suspended material. The screenings are discharged directly from the screen after transport and compaction in an integrated screenings press. In the following chamber of longitudinal grit trap, settleable material is separated through the reduction of flow velocity. The plant shall be equipped with grit trap aeration for removal of Fat, Oil and Grease. A horizontal shafted screw conveyor transports the separated solids (grit and organic particles) against flow direction to a grit classifying shafted screw which is integrated at the beginning of the grit trap. During their transport in the grit classifying screw the solids are statically dewatered prior to being discharged into a container. Compact Inlet Head works includes Rotary Drum screen/Band or perforated punch holes Screening system with conveyor system and an Optimal Coarse Bubble Aerated Grit diffuser system to avoid adverse effects on downstream treatment facilities with blower arrangement with Conveyor system in a Single fabrication unit which shall be installed on the RCC Platform with necessary staircase with proper access approach.

Incoming pumping main from Terminal Sewage Pumping Station (TSPS)/Intermediate Sewage Pumping Station (ISPS) shall be connected to the inlet of Combi Unit and Outlet shall be connected to Aeration Basin/SBR Basin/MBBR Tank/IFAS Tank system.

B. Constructional Features

The complete plant shall consist of units inclusive of longitudinal grit trap, fine rotary drum screen, screw conveyors for removal, transferring and dewatering the screenings and grit in shafted design.

Longitudinal grit trap shall be equipped with the provision of removal of Fat, Oil and Grease by means of aeration by Rotary Air blowers.

Compact system shall be fabricated by using minimum 8 mm SS 316 plates with reinforcement Angles, Channels and necessary Gazette plates sufficient thickness shall be welded to have robust and compact design and construction. Lifting hook/Lugs shall be welded for lifting the entire unit from ground level to the top of the RCC Platform. Total combi unit shall be anchored with proper grouting material (GP2) shall be used to avoid the vibration on the platform. Combi unit shall be supplied with minimum one standby unit. Combi unit shall be placed on the Platform with sufficient spacing between the two units adjacent to access each unit for regular operation and maintenance. Access platform of minimum 1.5 m shall be provided all around the units with handrailing.

Complete plant shall be prefabricated structure SS316 except the drives, motors. The plant shall be designed and fabricated so as to connect with the incoming sewer pipe my means of a flange connection.

Similarly, the outlet of the plant shall be connected to the downstream treatment process via flange connection.

The rotary drum screen basket should be a precisely welded construction. The perforated plate/ wedge wire surface which retains the screenings should be welded onto a supporting structure. Spirals of metal strips on the inner drum surface transport the screenings upwards and drop them into the trough. A brush fitted to the inner drum surface cleans the trough edge as the basket rotates. The screen basket at the bottom end is to be fixed to the screw by means of a strut, while on the upper end support is to be provided with several rollers. A brush or a polyurethane sealing on the baffle plate is to be used to seal the gap between the screen basket and channel.

C. Operation and Functional Features:

The machine starts when the screen level control level (or any other start signal) is reached. The screen drive motor operates as long as the start signal is active and transports the solids out of the channel. The water level in front of the screen falls again. The screen running time must be individually adjusted to each plant by programming a (selectable) follow-up time.

If the inflow is low, screenings may accumulate in front of the screen if screen starting is not effected via screen level control. To prevent accumulation of screenings, a time can be programmed after which the screen drive motor is necessarily switched on after a selectable standstill time. The screen drive motor will then operate according to the freely programmable follow-up time.

To protect the screen against mechanical damage, the electrical control is to be equipped with an overload relay. The machine stops immediately whenever the overload relay responds. After a pause of 2 seconds the screen drive motor is reversed for a programmable time. To avoid damage of the bottom shafted screw flight screen reversal has to be limited. This applies also to manual operation, i.e., even in manual mode the screen can only be reversed for the pre-defined time even if the key or button is operated longer. A new reversal is only possible after prior forward operation.

As soon as the start signal from the level control system responds, the machine starts to run forwards again after a waiting time of 10 seconds.

If the overload relay trips 3 times within 5 minutes, the machine is stopped, and a trouble is reported. The machine can only be re-started after reset of the fault.

If the Overload relay trips during screen reversal, the machine must immediately be stopped. A fault message is reported. The machine can only be re-started after reset of the fault.

If the current relay trips during screen operation in manual mode (forwards or reversal), the machine must immediately be stopped, and a fault message reported. The machine can only be re-started after reset of the fault.

The scope of supply shall include the Combi Unit with all accessories and appurtenances, including, but not limited to:

1. **Fine screen (4 mm) with screen conveyor with Compactor**

Mesh Band or Punched hole Screen Detail specification shall be same fine Screen specification as specified in the Part 8 Cl.no. 8.10.

2. **Screen Washer system**

Screen washer system as Spray nozzle bar shall be provided for cleaning of screen basket. A solenoid valve is to be provided to control the washing operation. The solenoid valve is controlled parallel to the forward operation of the screen motor drive. While the screen basket rotates, screenings are removed by means of the flat jet nozzles. Press zone washing system is to be provided. Activation of the press zone washing system effects cleaning of the press zone and press liquor collection chamber. For this purpose the solenoid valve for press zone washing is to be provided. The integrated screenings washing system shall be provided to wash out the faces contained within the screenings and return them to the biological process. Such screenings washing improves screenings dewatering efficiency.

Washing system consist of three washing stages: preliminary washing, washing with pressure, fine washing, Preliminary washing / washing with pressure is carried out by water supply via the solenoid valve. Fine washing: Three washing units on the rising pipe are connected with pressure hoses, The nozzles spray in an exactly defined angle onto the screenings while these are conveyed by the screw. Water supply is via a second solenoid valve on machine and bigger which is controlled separately (solenoid valve for fine washing). Tank cleaning system is to be provided for cleaning of the tank with solenoid valve.

3. Grit removal system with Grit washing system and Grease removal system

The Retention time for Grit and grease removal should be 2.5 minutes and above. For aerated plants a grease trap shall be provided. Floating particles are carried over to the attached grease trap more or less with the air roll of grit trap aeration. The grease is to be removed intermittently by an integrated grease paddle.

Wastewater flows into the grit removal zone, where the finer solids materials are still present in the wastewater are settled in the tank with the introduction of air, and the same has been conveyed to the hopper by a horizontal screw conveyor which is installed for grit removal conveys the grit particles in to a Grit washing system.

The Grit washing system is used to separate the grit and clean grit (sand, gravel) from wastewater, removing organic matter and preparing it for further processing or disposal. The cleaned grit is then discharged via a screw conveyor to a discharge bin or container, while the washed-out organics are typically returned to the wastewater flow.

The grease paddle ensures uniform removal of grease over the entire grease trap surface. The grease paddle pushes the grease into a collection chamber at the beginning of the plant from where it is pumped by an eccentric screw pump. For aerated grit traps, Rotary Lobe blower is to be provided for aeration. The individual air tubes can be adjusted to specific site requirements via separate ball valves.

System has a blower integrated and coarse bubble diffusers and a scum cleaning and removal device that contains air to prevent the rotary cleaner from clogging, grease are generated and forced to corner where a water nozzle system are moving and pushing grease to a rotary scraper which will concentrate and eliminate grease discharging it by gravity pipe into container. A Grease removal unit is integrated into the system to remove the oil and grease in the incoming sewage water. System have a blower integrated and coarse bubble diffusers, grease are generated and forced to corner where a water nozzle system are moving and pushing grease to a rotary scraper which will concentrate and eliminate grease discharging it by gravity pipe into container.

4. Discharge Chute

A Discharge chute stainless steel 316 shall be provided at the discharge part of the screw conveyor. The chute shall be constructed such that the screenings are blocked from being discharged.

5. Screw Conveyor with compactor

Technical specifications of Screening Conveyor

The Screening Conveyor shall be Shaft Screw Conveyor and applied for conveying the floating debris to the next facilities. The screening system shall be supplied with a shaft screw conveyor that will be used to convey the screenings to the automatic screenings press and discharge system that compacts, dewaters and discharges the screenings through a chute to the screenings storage system.

Dumping of the screenings on to the duty/standby conveyor opening shall be with the automatic deflection plate, which shall be positioned towards the conveyor which is selected from the LCP/SCADA for the duty and automatically towards the standby if duty conveyor trips. Position of this deflection plate shall be interfaced with PLC.

Screening wash compactor shall be suitable for washing and compacting the floating waste coming out of the duty and standby shaft screw conveyor in case of multiple screens, or directly from the screen in case of single screen installed in municipal wastewater pumping station or treatment plant.

Shaft screw conveyor shall be made of stainless steel of grade SS 316 and shall incorporate shaft spirals. Cover plates for shaft screw conveyors shall be provided along the entire conveyor length to contain splatter. Conveyor trough covers shall be made from 5 mm of specified grade of stainless-steel single piece formed sheet metal, not greater than 1000 mm in length, attached to the screw conveyor trough using toggle clamps. The cover shall also be of sufficiently tight fit to prevent the conveyed media from leaking out of the conveyors. A minimum 2.5 mm neoprene gasket of 50 durometer shall be applied with an appropriate adhesive to the mating surfaces of the trough covers.

Its structure shall have excellent durability to continuous running for long time. It shall be well considered of abrasion resistance, corrosion and vibration resistance. It should have a structure which is free from debris material clogging.

The spiral flighting for the shaft screw conveyors shall be designed to convey material without a center shaft. The spiral flights shall be designed with stability to prevent distortion and jumping in the trough while operating at design speed and design capacity. The spiral flighting shall be Stainless steel of grade SS 316.

Shaft conveyor trough liner material shall be an ultra-high molecular (UHMW) polyethylene with a minimum 12 mm thickness. There shall be two colored layers in the liner material to indicate wear. The liner shall extend the full length of the trough, covering the entire semicircular bottom portion of the trough. The liner shall be secured at intervals not to exceed 1000 mm, using specified stainless steel retaining clips of an approved design.

Screening wash compactor shall be made of stainless steel of grade SS 316. The wash compactor will receive the waste through inlet hopper and the waste shall get dropped into the conveying zone of the compactor main body.

Screw and liner shall have rigid thickness for resisting corrosion and abrasion caused during carrying of debris. Its structure shall be designed not to invite biting and clogging. Casing shall be equipped with inspection port to the necessity as well as for cleaning convenience. Driving device shall have overload limiting switch for avoiding broken situation caused by overloading.

The conveying zone shall have perforations at the bottom so that the water coming along with the wet screening is dropped into the dewatering trough. The dewatering trough will have a set of nozzles positioned upwards so that the screening particles chocking the perforations will be removed by the force of spray water. The construction of the dewatering trough shall be inclined towards the drive end so as to enable the flow of water to the drain hole provided with an elbow connection. The compactor main body shall also have a drain hole with an elbow connection.

In the conveying zone there shall not be any impeller wheel or any other mechanical breaking device. The breaking up of organic matter shall be done solely by water through an assembly of nozzles connected with solenoid valves in a special washing zone between the conveying and the compaction zone. The screening shall move towards the compaction zone by a shafted screw of a constant pitch connected to a drive shaft. This drive shaft shall be connected to the drive unit through axial and radial bearings.

An electronic device shall operate the drive unit of the spiral in a forward reverse mode, separated by a stand still period. The time of forward and reverse operation as well as the stand still time shall be freely adjustable.

The non-drive end of the screw shall have the flight of reduced pitch in the compaction zone. For achieving better strength at non-drive end, the screw must be supported by wear bars connected to the wash press main body and reinforced with double flights of defined pitch.

An elephant trunk shape outlet tube shall be connected to the compactor body with a flanged connection. An elbow shall be provided at the flanged connection to carry the washed screening in the reduction tube. The reduction tube shall be divergent to ease the push of the washed screening upward in to the outlet tube. The end of the reduction tube shall have an elbow with discharge plate/chute to enable the collection of the screenings in bagging units or a container.

The Screening wash compactor shall remove the organic material by washing and compaction thus reducing the volume and weight by 50%.

The main body of Screening wash compactor shall have a material thickness of minimum 3 mm and the bottom of the compactor main body shall be perforated with 5 mm holes.

The screw flights of wash compactor shall have a minimum thickness of 12 mm and at the end of compaction zone, there shall be wear bars of 10 mm thickness bolted to the wash press main body/tube for easy replacement.

The elephant trunk shaped outlet tube shall be diverging to prevent the waste getting clogged. The connection of the outlet tube to the main body shall be flanged type. All the bend fittings (elbows) in the outlet tube shall be long radius design.

Frequency Inverter shall be provided for Forward-reverse-forward motion of the screw and as overload protection device.

The gearbox of screw conveyor and wash compactor shall be hollow shaft, parallel helical gear unit have a minimum service factor of 1.2, oil bath lubricated with oil sealing. The motor shall be of TEFC type with minimum IP 55 protection & Class F insulation and be suitable for operation on 3 phase, 415V and frequency of 50 Hz. The drive shaft must be precisely machined and shall have radial and axial bearings.

The common control panel shall have IP 55 protection, painted with epoxy paint and shall be comprising of

- Mushroom head emergency stop.
- Overload relays for motor protection.
- Circuitry to operate the Screening conveyor and wash compactor with signal for start command from screen motor start and delay-timer based stop command after the screen motor stops.
- Selector switch to operate the Screening conveyor and wash compactor in Auto, manual and remote mode.
- Provision for suitable PLC circuitry shall be provided in case requirement of connectivity with SCADA system.

The Screw conveyor and wash compactor shall be supplied factory assembled and duly tested at manufacturer's works before dispatch. Upon receipt at site these shall be installed resting on the channel floor and mechanically or chemically anchored on to the platform in a way that there are minimum chances of misalignment.

Accessories

Anchor bolts and nuts	1 set
Special tools	1 set
Flexible joint for inlet and outlet	1 set
Liner (for spare)	1 set

6. Portable Screenings Container

Portable screenings containers made of galvanized steel shall be provided to store the screenings until time of pick up. Minimum two Screenings Containers shall be provided at the screening chamber. The container shall have capacity of approximate 2.0 cum and shall be of a convenient height to permit the discharge of screenings directly into the container without having to transfer the screenings manually. The containers shall have hinged covers and their design shall permit their being lifted by an overhead hoist or packer truck. The container will have four wheels each of minimum 40 cm diameter, Tyre type. The maximum height of container including wheels shall be 66 cms. The sides shall be constructed of 12-gauge steel. The bottom of container shall be made of 5 mm plate steel. The containers shall be reinforced with 50 mm x 50 mm x 5 mm angle.

The system will have an Odour enclosure to treat as a meeting Odour intensity to a level that minimizes adverse effects on the living environment at Near the exhaust duct outlet of the deodorizing device with the pipe in the screen zone, grit/grease tank, and sand washer.

a) Material of Construction

The material of construction of the Combi Unit shall be grade 316L stainless steel and an Odour control system, a Carbon filter shall be FRP Vessel.

b) Corrosion Resistance

All metal parts of the screen equipment that are in contact with the sewage shall be constructed of a suitable grade of corrosion-resistant stainless steel 316 L, and odour gases of FRP vessel and ducting.

c) Performance criterion

90 % of grit removal for particle size ≥ 0,2 mm, Specific gravity of grit particle shall be 2.65

d) Motor Specifications

Premium efficiency class (IE3 and above), with IP55 Protection, Nominal voltage 415V±10% and nominal frequency 50 Hz, Design ambience temperature shall be 45 Degree Celsius.

e) Working Stress and Design

The design of all parts shall ensure that under the most onerous of conditions, they will not be damaged or corroded. Any joint that will need to be dismantled during maintenance shall be made with anti-corrosion type fasteners. All spare parts shall be fully interchangeable with the original part. If the spare part is unavailable due to cessation of production, the Contractor shall give notice to the Employer in writing, detailing the options available to the Contractor.

All parts shall be designed to minimize the risk of fire and consequential damage. All parts shall be designed to prevent the ingress of vermin, dust, and dirt. All electrically live or moving parts shall be adequately guarded to prevent accidental contact.

f) Outlet Guarantee Parameters of Combi Unit

Sl. No.	Parameters	Value
a)	Dry solids content in debris	Up to 30%
b)	Waste volume reduction	Up to 50%
c)	Waste weight reduction	Up to 60%
d)	Grit removal efficiency for particles > 0.200mm (200 Microns) > 0.100mm (100 Microns)	 90% 85%
e)	Final dewatered grit from the Grit washer	< 3% on dry basis
f)	H2S Outlet of OCU	< 0.5 ppm

g) Material of construction:

Sl. No.	Item Description	Particulars
A	**Compactor Tank**	
i.	Material Of Construction with Partitions inside the Tank	Minimum 8 mm SS 316 plates with reinforcement Angles, Channels, and necessary Gazette plates
ii.	Tank Structure with Partitions	Rectangular with Hopper Bottom
iii.	Inlet and Outlet connection	SS 316, Flanged type (PN 10 Rating)
iv.	Opening size	Pipe Diameter equal to incoming Pumping main size
v.	Top Cover for Odour Control unit	SS 316 Plate with minimum 5 mm thick, Odour control unit Flange connection on the top cover
vi.	Overflow Pipe	Overflow Pipe provision with DI piping upto nearest drain Point
B	**Screen and Compactor**	
i.	Fine Screen Type	Automatic Rotary Drum Screen or Punched Hole/mesh Fine Screen
ii.	Screen Opening size	4 mm (Maximum)
iii.	Screen Mesh or Plate thickness	Minimum 4 mm
iv.	Top, Bottom & Side Plates	Minimum 5 mm thick
v.	Discharge chute	Minimum 4 mm thick
vi.	Screw Conveyor type	Shafted or Shaftless both are accepted
vii.	Drum/Screen Cleaning	By Brush fitted on Spiral or Water Spray jet type by Plant Water or Motorised Brush cleaning for Fine Band/Mesh Screen
viii.	Rotation Speed	6 RPM (Maximum)
ix.	Geared Motor Voltage/Frequency/Degree of Protection/ Insulation type	415V/ 50Hz/ IP55/ Class F
x.	**Material of construction for Rotary Drum Screen**	
a.	Screw Conveyor with wash compactor	SS 316
b.	Drum / Punched/ Mesh Plate	SS 316
c.	Channel Sealing and Drive Shaft	SS 316
d.	Water Nozzle	SS 316
e.	Brush	Nylon
xi.	**Material of construction for Mesh Band/Punched Hole Fine Screen**	
a.	Screen Filter step/Mesh or Plate	Stainless Steel ASTM A 240, Grade 316L

Sl. No.	Item Description	Particulars
b.	Screen Frame (Top, Bottom, Adjacent Sides and Dead Plates)	Stainless Steel ASTM A 240, Grade 316
c.	Drive Chain & Sprocket	Stainless Steel ASTM A 240, Grade 316L/ Duplex Stainless Steel SAF 2205
d.	Drive Shaft	Stainless Steel ASTM A 276, Grade 316
e.	All Fasteners and Anchor Bolts	Stainless Steel, Grade 316
f.	Discharge chute	Stainless Steel ASTM A 240, Grade 316
g.	Spray bars & jet nozzles	Stainless Steel ASTM A 240, Grade 316L
xii.	**Screw Conveyor and Compactor**	
a.	Screw	SS 316
b.	Screw trough	SS 316
c.	Screw cover	SS 316
d.	Liner	Ultra-High Molecular Polyethylene (UHMPE)
C	**Areated Grit System and Grease Removal unit**	
i.	Blower Type	Rotary Lobe Blower
ii.	Installation Location	At Ground Level Near to the Inlet Head Works with proper RCC Building
iii.	Capacity and Pressure	As per vendor Recommendation
iv.	Areated Grit Piping	Coarse Bubble type with 5 mm Pore size (maximum)
v.	Material of Construction of piping	SS 316 L with minimum Schedule 40S Seamless
vi.	Pipe Supports for Air Piping	SS 316 L
vii.	Grit Conveyor and Screw Classifier	Shafted or Shaftless both are accepted
viii.	Material of Construction of Grit Conveyor and Screw Classifier	
a.	Screw	SS 316
b.	Screw trough	SS 316
c.	Screw cover	SS 316
d.	Liner	Ultra-High Molecular Polyethylene (UHMPE)
ix.	Geared Motor Voltage/Frequency/Degree of Protection/ Insulation type	415V/ 50Hz/ IP55/ Class F
x.	Settling Tank at end of unit	Partition within the compactor unit with Effluent Outlet SS 316, Flanged type (PN 10 Rating)

7. Odour Control system with Odour enclosure for the complete system connected to COMPACT Pre-Treatment System (COMBI Unit)

A. Dual Stage Odour Control System

This system includes a carbon adsorber equipped demisters, the best granular activated carbon, Acid-resistant fans, Air flow meters, Pressure gauges and motor assembly, interconnecting Acid-resistant ductwork, control panel, isolation and flow balancing dampers, accessories, manufacturer's services, and inspections. The vessel, fan (s) with motor and carbon work, as a system, are the end products to achieve standardisation for appearance, operation, maintenance, spare parts, and the manufacturer's

services. The Odour Control System will contain Coconut shell or coal base coated with chemicals **or** bituminous coal-based pelletized activated carbon, which is regenerable by an activation of activated carbon at a dedicated factory, or with potable or irrigation water with Cassey Soda solution. The incoming H2S values are averaged over the year, and it is normal to find fluctuations in the H2S concentration (night versus daytime, cold versus hot season). The offered equipment can handle fluctuations.

If the removal performance of the activated carbon is sued, evaluated by constantly measuring Odour level and replacing any breakthrough activated carbon periodically, as well as It is necessary to control the concentration of caustic soda water.

The odour control equipment is designed to remove at least 99.9 % of the odorous gases such as H_2S, from air within a temperature range of 5 to 55 degrees C and a humidity range of 10 to 100 %. This "Green" product range needs no chemicals for regeneration.

The main odorous gases commonly found in sewage air are:

- Hydrogen sulphide (an inorganic acid)
- Indole and skatole (organic molecules)
- Methyl mercaptans (sulphur-based organic molecules)
- Methylamine (nitrogen-based organic molecules)

It is necessary to implement a sufficient ventilation rate (=number of air changes), depending on the amount and type of odour, size and type of the tanks. This amount of air is taken by the centrifugal fan, which feeds the adsorption system.

The air moves to the section with water, regenerable activated carbon. In this section, full deodorisation is obtained. The treated air is free of objectionable odours (such as H_2S, mercaptan, Disulphide…). To restore the H_2S capacity of the carbon in the filter, contacting the carbon with water is required in the regeneration process. During regeneration (only after more than 1 year of service) of the second stage, the fan is stopped (takes only a few hours). Regeneration of the carbon is done with water

Potable water or irrigation / treated effluent at 2.5 bar to wash the saturated carbon. Approximately 10 bed volumes of water are required. The regeneration takes only a few hours. The carbon can be regenerated several times (up to 10 times) depending on the load in the foul air. Once the carbon is exhausted, it can be replaced with virgin carbon.

The filtered water leaves the system through an outlet pipe placed at the upper level for downstream treatment.

The odour control system shall be dual stage process, with a suction fan to extract the odorous air from the process the area, air pass through stage 1 (biological scrubber) and stage 2 (activated carbon) system before releasing to atmosphere.

Stage 1:

The system is designed to remove hydrogen sulphide (H2S) by providing an environment providing the growth of acidophilic, sulphur oxidizing bacteria. The system consists of media, is an inert mineral, porous material designed to resist compaction and degradation from acidic sulphates of the biological oxidation of the hydrogen sulphide. Irrigation water with nutrients will be supplied for continuous humidification of the media.

Stage 2:

It is used to remove any remaining hydrogen sulphide as well as other odorous compounds. The second stage media shall be pelletized activated carbon made of coconut shell, specially made for wastewater odour removal application. Media shall be water regenerable at site with potable / irrigation water.

Water and acidic sulphate by products washed from the media leave the system through the drain piping at the bottom of the vessel and are returned to wet well or wastewater stream. A water tap (P trap) on the drain line prevents odorous air from escaping through the drain.

The cleaned air is discharge to the atmosphere through one stack at the top of the unit. Treated air quality shall be continuously monitored by hydrogen sulphide sensor.

B. Guidance for Air contaminants and quality requirements:

Item	**Requirements**
Inlet H2S concentration	Peak H2S concentration 250ppm Average H2S concentration 100ppm
Outlet H2S concentration at the odour control unit stack	<0.5 ppm
Removal Efficiency	Hydrogen Sulphide >99%
Flow rate	Minimum 12 x airspace volume / hour
Design Ambient temperature	10-50 Degree C
Design Humidity	0-100%

C. Equipment Specification

a) First stage biological scrubber shall consist of media for bacterial growth which shall be made of inert material, porous designed to resist compaction and degradation acidic environment. Media shall meet following minimum criteria to be met:

Material	Inert mineral porous media
Particle size	15-60mm
Bulk density	180-320 Kg/m3

Water adsorption	18-20%

b) Second stage shall be based on Activated carbon, media shall be derived from virgin coconut shells, pelletized to suit the application. This shall be water regenerable at site. Minimum life of the activated carbon in the first fill shall be 5 years.

c) The type of activated carbon selected must be effective in dealing with odour arising from maximum concentrations of hydrogen sulphide and other sewer gases

d) Activated carbon shall minimum meet the following specification:

Carbon Substrate	Coconut shell based
Regeneration	On site, water regenerable
CTC, minimum	50
Mean particle diameter	4 mm
Apparent density minimum	450±50 kg/m3
Hardness number, minimum	95
Moisture, maximum	10 percent
H2S adsorption capacity	0.16g/cc

a) Vessels and fittings shall be manufactured from a chemically resistant grade Vinyl ester based FRP unless otherwise stated; suitable for H_2S gas applications.

b) Prefilter shall be manufactured in resilient plastic random mesh which are washable and long lasting. Housing shall be manufactured by chemically resistant grade Vinyl ester based FRP. Cleaning spray nozzles and drain shall be provided for Pre-filter for CIP.

c) Where the odour control system is fan assisted; all parts exposed to the fumes shall be chemically resistant Vinyl Ester based FRVE material and the motor and drive shall be sealed from the exhaust gas path.

e) Fan motors shall be belt driven and suitable for installation IE3 rated comply with electric motors specifications. Fan shall controlled via a VFD for any speed variation purpose.

f) Sample probes: each vessel shall have three 40 mm diameter sample probes per bed. The sample probes shall be adequate to provide suitable extraction of media samples from the bed. The sample probes shall extend outside the vessel wall and shall be isolated with a uPVC ball valve.

g) Differential pressure gauge: One each set of DPI to monitor the pressure drop across the carbon bed, pre-filter and across the bio-scrubber unit.

h) H2S monitor: One set of portable H2S gas detectors is to be provided to monitor the outlet gas concentration at the second-stage discharge stack. The unit should have a display showing the concentration of H2S.

i) U-PVC drainage valves and pipework routed back to the wet well to drain off any condensate/regeneration liquid from the prefilters.

j) Extraction suction line and valves shall be non-corrosive uPVC/Polypropylene/FRP material.

k) Control panel shall be IP55 rated enclosure for outdoor application and shall be installed on the vessel or beside the unit. Control panel housing shall be made of FRP cabinet, operational parameters control shall be with PLC & HMI with a provision for connecting to Main SCADA of the plant.

l) There shall be a water panel housed with flowmeters and other operating valves for the Biological unit, housed in an FRP cabinet, shall be installed on the biological unit vessel or beside the vessel.

m) Screen chambers shall be covered with SS 316 Plate to avoid releasing the odour gases to the ambient. It shall be a removal type for maintenance.

8. Activated Carbon Adsorption System

Odorous air in contact with activated carbon media, will adsorb the hydrogen sulphide and other odour gases present in the air, and will release the purified air to atmosphere. The media shall be pelletized activated carbon made of coconut shell, specially made for wastewater odour removal application. Media shall be water regenerable at site with potable / irrigation water.

Water and acidic sulphate by products washed from the media leave the system through the drain piping at the bottom of the vessel and are returned to wet well or wastewater stream.

The cleaned air is discharge to the atmosphere through one stack at the top of the unit. Treated air quality shall be continuously monitored by hydrogen sulphide sensor.

(a) Guidance for Air contaminants and quality requirements:

Item	**Requirements**
Inlet H2S concentration	Peak H2S concentration 250ppm Average H2S concentration 100ppm
Outlet H2S concentration at the odour control unit stack	<0.5 ppm
Removal Efficiency	Hydrogen Sulphide >99%
Flow rate	For Combi unit Channel, Minimum 12 x airspace volume / hour.
Design Ambient temperature	10-50 Degree C
Design Humidity	0-100%

(b) Equipment Specification

a) Activated carbon, media shall be derived from virgin coconut shells, pelletized to suit the application. This shall be water regenerable at site. Minimum life of the activated carbon in the first fill shall be 5 years.

b) The type of activated carbon selected must be effective in dealing with odour arising from maximum concentrations of hydrogen sulphide and other sewer gases

c) Activated carbon shall minimum meet the following specification:

Carbon Substrate	:	Coconut shell based
Regeneration	:	On site, water regenerable
CTC, minimum	:	50
Mean particle diameter	:	4 mm
Apparent density minimum	:	450±50 kg/m3
Hardness number, minimum	:	95
Moisture, maximum	:	10 percent
H2S adsorption capacity	:	0.16 g/cc

d) Vessels and fittings shall be manufactured from a chemically resistant grade Vinyl ester based FRP unless otherwise stated; suitable for H_2S gas applications.

e) Prefilter shall be manufactured in resilient plastic random mesh which are washable and long lasting. Housing shall be manufactured by chemically resistant grade Vinyl ester based FRP. Cleaning spray nozzles and drain shall be provided for Pre-filter for CIP.

f) Where the odour control system is fan assisted; all parts exposed to the fumes shall be chemically resistant Vinyl Ester based FRVE material and the motor and drive shall be sealed from the exhaust gas path.

d) Fan motors shall be belt driven and suitable for installation IE3 rated comply with electric motors specifications.

e) Sample probes: each vessel shall have three 40 mm diameter sample probes per bed. The sample probes shall be adequate to provide suitable extraction of media samples from the bed. The sample probes shall extend outside the vessel wall and shall be isolated with a uPVC ball valve.

f) Differential pressure gauge: One each set of DPI to monitor the pressure drop across the carbon bed, pre-filter and across bio-scrubber unit.

g) H2S monitor: One set of portable H2S gas detector to be provided to monitor the outlet gas concentration at the discharge stack. The unit should have a display showing the concentration of H2S.

h) U-PVC drainage valves and pipework routed back to the wet well to drain off any condensate/regeneration liquid from the prefilters.

i) Extraction suction line and valves shall be non-corrosive uPVC/Polypropylene/FRP material.

j) Control panel shall be IP56 rated enclosure for outdoor application, shall be installed on the vessel or beside the unit.

k) The air changes shall be created by a dual centrifugal fan combination, of which one is working and the other is on standby. The "switch over" shall be controlled by the PLC in the control panel. No manual operations (opening closing of valves) shall be required for preventing backflow of untreated air. The backflow of air shall be prevented by integrated non return valves mounted in the suction piping or discharge piping.

l) The fans shall be driven directly by the motor. Belt drive is not acceptable. The bidder shall select a centrifugal fan in 316L with not less than 75 % efficiency if the required motor power is 3 kW or more. The fan speed at nominal airflow shall not exceed 1500 rpm for system larger than 7500 M^3/Hr. The fans shall be mounted on rubber anti vibration shoes. Inlet and outlet pipes shall be flexible by using UV and gas resistant rubber sleeves and 316L spanners.

m) The motor shall be safety class IP 55 suitable for continuous exposure to 55 °C temperature. A PTC controller and standby heating shall be integrated into each motor housing. With external contact or by activating on switch on the control panel, the fans shall produce 33 % more flow. The increase in flow shall be obtained by increasing the fan speed. The fan speed and time shall be programmed in the system PLC, which controls the fan motor VFD. The bidder has the option to pre - program the speed or to install a fixed anemometer in the treated air discharge stack. The increase in speed shall be terminated after 2 hours or at a different time given by the consultant or the customer. The temporary "boosted" extraction rate shall allow a safer atmosphere inside the odour source for inspection. The adsorption vessel shall be able to handle the boosted airflow.

n) The fan shall be preferably centrifugal direct-driven type constructed from corrosion resistant stainless steel 316L material with vibration free mountings for continuous operation.

o) Duty / standby fans shall be provided for each Biological Odour Control system. Each fan shall have VFD driven motor with the capacity and power to deliver the required volume of air against the total pressure losses in the air intake, collection systems, biological media, ductwork, and dampers to the fans and exiting out of the stack.

p) Fan Motor should be selected with high efficiency, power allowance as required by process requirements and sized for maximum allowed rotation of the selected fan model at nominal grid voltage and frequency.

(c) Documentation

The following information shall as a minimum be submitted with the proposal. The accuracy and completeness of the submission of all the requested data will form part of the tender evaluation. All information shall be submitted in both hard copy originals and as an electronic copy.

- Compliance statement to this technical specification.
- Manufacturer company profile
- Local supplier company profile
- Basic description of proposed OCU system, including process flow description.
- The Bidder's Scope of Supply, including limits of contract and any assumptions made by the Bidder.
- List of main equipment items, motor list, and instrument list.
- Details of media offered, including media life guarantee and data sheet.
- Reference lists of similar installations demonstrating manufacturer previous experience.

(d) Manufacturer Experience & Quality Assurance:

Odour control systems are a specialized treatment process, to make sure the performance stability, longevity of the systems offered, lifetime equipment support, below are the minimum criteria to be met by Odour control system manufacturer.

a) Odour control system manufacture shall be a specialist vendor for odour control equipment.
b) Manufacturer and his Sub vendor shall be Indian origin or abroad and shall have manufacturer facility in India/abroad for consumable media (activated carbon). To ensure, lifetime support throughout the life of the equipment.
c) Manufacture should be an ISO 9001:2015 certified manufacture in Air purification system & Activated carbon manufacturing process, to make sure the quality of products.
d) Manufacturer shall have media performance testing facility in-house to test initial media performance and to test media life analysis during operation. This is to ensure optimum usage of filtration media.
e) Manufacturer shall have at least 10 Oduor control unit's installations globally, 5 installation specifically in municipal wastewater for odour removal application in last 5 years for which Performance certificates and Purchase Order copies of successfully executed works with documentary Proof.

8.18 Aeration system with allied Equipments

8.18.1 Tubular Type Diffusers

(a) In this subsurface aeration system, air is introduced by diffusers submerged in waste water.

(b) The diffuser shall be fine bubble membrane tube type diffuser consisting of a single piece injection-molded polypropylene/uPVC tube surrounded by a membrane sleeve with maximum outer diameter (OD) shall not be more than 90 mm. The porous membrane material shall be either EPDM or SILICON based on the process requirement and durability for long run. Membrane retainer clamps with fasteners shall be of SS 316, clamping shall be done on either side of the membrane.

(c) No drilled holes on the support tubes are permitted and only channel type arrangement for entry of air into membrane is desired. Air opening on the membrane should be 0.5 to 2.5 mm with staggered perforations.

(d) The design of membrane sleeve should prohibit clogging of the pores which are self-closing when air flow/pressure is interrupted. The membrane should have anti adhesive surface which is resistive to grease, oil, hydrocarbons & precipitating chemicals and be resistant to microbial growth.

(e) The air distribution channel should extend over the entire effective length for an even distribution of air for bubble formation.

(f) These membranes shall be provided preferably with lower perforation sizes with suitable perforation pattern which when applied with a lower diffuser throughput rate and correct distribution of the diffusers on the bioreactor floor will result in a very high oxygen transfer efficiency (OTE).

(g) The rising velocity of bubble should be lower.

(h) The bubble should retain a solid spherical shape. The bubbles produced from the diffuser shall be minimum 0.5 mm. The flow of fine bubble shall provide gentle mixing which prevents flock shear.

(i) Bubble should move in a helical fashion for lower bubble diameter so that it travels a longer path. The membrane tube diffuser shall have complete system i.e. air header, support pipes, locking bolts etc.

(j) The aeration system shall be removable without needing to drain or partially drain the tanks.

(k) The Standard Oxygen Transfer Rate (SOTR) operating ranges shall be achieved with all aeration zones operating at varying air supply rates.

(l) Contractors should provide their recommended minimum airflow rates for each zone in order for their diffusers to maintain the activated sludge mixed liquor suspended solids (MLSS) in suspension and avoid deposition of sludge in the Aeration Tank/Bioreactor. Provide fine bubble membrane type diffusers of a type that will prevent backflow. The Aeration system shall be suitable for prolonged isolation of the air supply, while preventing backflow seepage through the diffusers.

(m) Provide the membrane fixed to the membrane holder in a manner which does not introduce unbalanced stresses and increases sealing pressures as the air flow rate to the diffuser risers.

(n) Provide a back flow prevention device built integrally with the diffuser that prevents backflow into the diffuser and air piping.

(o) Provide an airflow control orifice to ensure even airflow distribution among all diffusers. Ensure that the airflow to any one diffuser is within plus or minus 5% of the average value, at all airflows.

(p) Provide a maximum diffuser flux rate such that the stress in the diffuser material is within elastic loading limits with a safety factor of at least 10. Submit test results, calculations, and any other documentation to exhibit that the membrane material will be able to withstand operating loads without undue stress or strain leading to failure in compression or shear, or creating significant mechanical creep of the material which would impair functioning or would cause enlargement of the membrane perforations or holes.

(q) Provide the tolerances of the diffusers and the diffuser mounting bases such that any diffuser and any gasket may be assembled onto any mounting base and provide a seal capable of withstanding the applied hydrostatic and/or pneumatic head.

(r) Provide diffusers mounted by the action of a threaded component that shall require measurement of the applied torque to the threaded component during tightening. The torque measurement shall lie within the range of torques specified by the diffuser equipment supplier.

(s) Provide diffuser material resistant to chemical attack, UV light, weathering and aging. Submit test results, certifying the integrity of the membrane. Provide data indicating the susceptibility of the membrane material to attack by various chemicals.

(t) Provide all rubber components manufactured from synthetic rubber materials proven to be resistant to corrosion, degeneration or abrasion in the environments proposed.

(u) Provide diffusers capable of withstanding a maximum differential pressure of 30 kPa and a maximum air temperature of 80˚C. Provide protective storage of rubber and plastic components of diffusers prior to installation.

(v) Provide effective cover to the diffusers after installation to protect them against physical damage and the ingress of dust and dirt before filling the new Tanks with water.

(w) The fixed diffuser arrangement system should provide equal distribution in the aeration basin and there should not be any dead zones in the basin. Diffusers should be installed at equidistant intervals and shall be anchored & grouted with SS 316 fasteners and SS 316 clamping arrangement.

(x) Complete diffuser grid piping shall be assembled at original factory and site fabrication of diffuser is not acceptable.

(y) Furnish all components necessary to provide a complete mixing and aeration system. Work shall include but not necessarily be limited to the following:

- ✓ Flanged connections (SS 316) at the upstream side of each drop leg for connection to an isolation double flanged metal seated Butterfly valve Gear operated.
- ✓ Stainless steel Drop legs (SS 316).
- ✓ Slip joint connections to the air distribution header (SS 316).
- ✓ Stainless steel Air distribution headers (SS 316).
- ✓ Diffuser connectors (SS 316).
- ✓ Anchored Supports (SS 316) as necessary.
- ✓ Gaskets.
- ✓ Header joints (SS 316).
- ✓ Bolts, nuts and washers (SS 316).

(z) The Diffusers should be able to withstand high blower air and water temperature.

(aa) The air pressure that discharges oxygen / air into the sewage shall be generated as air bubbles that overcome the depth of tank and loss resistance of the diffusers.

(bb) The main cause of blockage of the diffusers due to solid matter is that when the oxygen supply to the aeration tanks is stopped, the inside of the air pipe instantaneously becomes negative pressure, and then, water depth pressure is applied, so MLSS water passes through the holes in the diffuser to pipe as backflow to the diffusers and its's pipe.

(cc) On the other hand, when bubbles are released from the air diffusers, a swirl flow shall be generated near the surface of the diffusers, so that the sewage may be slightly caught in a hole near the surface of the diffuser.

(dd) The sludge water that has entered the diffuser pipe shall remain in the inner surface of the air supply pipe / inside the diffuser, and some of solids is not removed even when the compressed air supply is resumed. Due to compressed high-temperature air (about 60-80 ° C), the deposit becomes dry solid and causes clogging and this may lead to cases where the installed membrane diffuser may bust.

(ee) In order to extend the service life of the diffusers and reduce repair costs, the structure of diffuser shall be excellent in durability, does not clog, maintains high dissolution efficiency, and ensures easy replacement work.

(ff) The performance conditions of the Tubular type aeration shall be minimum performance guarantee for damage, clogging, and dissolution efficiency of the diffuser is 5 years.

(gg) Contractor shall provide back flow prevention mechanisms / check valve inside each diffuser. This is to prevent intrusion of liquid and/or solids into diffuser and air piping under normal operating conditions of aeration system.

8.18.2 Diffuser Assembly

- ✓ Provide orifice flow control to ensure orifice head loss is at least 2.5 times the head loss in the air header at all air flow rates in the diffuser's design operating range.

8.18.3 Air Header and Drop legs

(a) Header and drop legs shall be constructed of 316 stainless steel.

1. Bottom elevation of the air distribution header shall be same throughout the tank.
2. Design connections between sections of the air distribution header to allow individual header sections to rotate independently of adjacent header sections.
3. Header dimensions shall conform to dimensional tolerances specified in ASTM A554-89 and ASTM A530-87.

(b) Furnish a drop leg from the air main connection at the top of the tank.

1. Provide a slip joint connection between the drop leg and distribution header.
2. Support the drop leg from the connection at the air header.

(c) Use factory welding only; field welding shall not be allowed.

1. Wire brush outside of each weld area.
2. Remove all discoloration and deposits left by welding by pickling.
3. Factory weld all diffuser connections. Stiffen both the diffuser connectors and the headers to withstand a moment of 56.5 Nm. at the connector without permanent deformation.

(d) Passivate all SS 316 assemblies and parts after fabrication by immersion in a pickling solution of 6 percent nitric acid and 3 percent hydrofluoric acid at 60° C for a minimum of 15 minutes.

1. Neutralize by immersion in a tri-sodium phosphate rinse.
2. Submit certificate that this has been done.

8.18.4 Supports and Anchors

(a) Provide wall and floor mounting supports for all drop legs and air headers as necessary to anchor firmly on the wall and to the bottom of the tank and as specified herein.

(b) Anchor supports to concrete walls and floors using stainless steel expansion bolts sized and spaced as required for the loads encountered.

(c) Design supports to allow leveling the air header and diffuser assemblies to within specified tolerances.

(d) Provide expansion couplings in the drop legs and air headers as necessary to accommodate anticipated thermal expansion and contraction.

1. Submit expansion coupling design as well as computations for sizing.

8.18.5 Spare Parts

Provide spare parts in the quantities indicated.

Item	Quantity
Diffuser Assemblies	5%
Orifice Inserts	5%

The Spare part shall be maintained/repurchased at all times during O&M period.

8.18.6 Installation

(a) Install all components in accordance with the manufacturer's instructions and recommendations.

(b) Install all diffusers to within +/- 10 mm of a common horizontal plane.

8.18.7 Air supply Pipe Work

i. General design Criteria

Many factors need to be incorporated in the design of the air distribution pipe work to minimize the potential of noise problems occurring. Factors to be considered in the design of the air pipe work to be minimize noise level shall include:

a) The diameter of the pipe work, to keep velocity low.
b) The connection of the blower discharge pipes to the manifold should be "Y", not at right angles.
c) No blind flange at the end of the manifold.
d) The manifold shall be designed to ensure air travels in one direction.
e) The air pipe work shall be designed to minimize changes of direction and use large radius bends.

f) Flexible connections shall be provided between the diffuser assembly units and the main air supply pipe work to allow for any differential movements.
g) Expansion and contraction shall be fully allowed for in the design and installation of the air distribution pipe work.
h) Rain taps shall be provided on the air pipe work to allow draining of moisture.
i) The pipe work and the support brackets shall be galvanized steel.
j) Pipe work shall have inbuilt flexibility such as packer flanges for reasonable construction tolerances on the structures to which it is attached.
k) In addition, consideration should be given to fixing piping materials that can withstand the compressive heat of air and shrinkage pressure of piping caused by direct sunlight.
l) If the pressure in the piping is negative due to a decrease in compressed air pressure due to the stop of aeration, a check valve should be considered.

Pipe shall be designed to ensure the efficient operation of the aeration system and compliance with the noise limitations. All valves in the air delivery system shall be correctly selected for the duty. Calculations of Cv (Head loss co-efficient) values for the range of flows and pressure losses across each valve should be prepared to ensure that each valve has adequate range of controllability for the duty.

However, the air piping submerged in sewage has to be in SS316 confirming to IS specification. Two spare drop pipes shall be supplied by the operator one for each compartment. This will be used to replace the choked diffusers drop pipe or on preventive basis on rotation. The choked one will be attended to and used as spare drop pipe.

ii. Air supply Headers

The air supply headers run from the main air distribution pipe work to the down comers. Pipe work shall have inbuilt flexibility such as packer flanges for future modifications and to allow for reasonable construction tolerances on the structures to which it is attached. An isolation valve for each main air supply pipe shall be installed at the point of connection to the main distribution pipe work. The design of the main air supply header shall incorporate all components necessary to enable the easy connection of the main distribution pipe work to the main air supply header.

iii. Blower Discharge Pipe Work

The Discharge pipe work from each blower shall be connected to a common manifold. Flexible connections shall be provided between the blower assembly units and the discharge pipe work to allow for any differential movements. The design of the manifold pipe work shall incorporate all components necessary to enable the easy connection to the main distribution pipe work.

iv. Air Flow Measurement

The amount of air being supplied to each air supply header shall be measured by the installation of flow measuring devices. The flow measuring devices shall be suitable for the intended application. The sensor assembly shall be supplied with suitable fittings which shall enable easy removal during maintenance. The accuracy of the flow meter shall be within 5% of the minimum design flow rate. The installation shall provide adequate length of straight pipe upstream and downstream of the flow meter to ensure the accuracy of the meter is attained. Pressure and temperature sensors shall be provided to measure the pressure and temperature of the air in the pipe, upstream of the flow meter device.
Pressure and temperature compensation measurements shall be provided for volumetric correction if the control air is based on airflow rate.

8.18.8 High Speed Turbo Blower

Turbo blowers are single-stage, high speed gearless air cooled radial turbo blowers designed to meet varying flow and pressure requirements in various processes. The system shall include factory assembled high speed turbo blower with a modern frequency controlled, gearless driven machine along with lubricant-free aerodynamic/Permanent magnet bearings, guarantees an economical, reliable and maintenance-free operation.

Turbo Blowers employ the high precision machined cast impellers, hydrodynamic air foil/Permanent magnetic bearings (air-lubricated), highly efficient Permanent Magnet motors and sensor-less Invertor drives, which eliminate the complicated gear trains or pulley & belt to provide considerable energy savings without much scheduled maintenance and with very low level of noise. Acoustically enclosed unit with noise not exceeding 85 dBA at distance of 1.86 meter from periphery of the Blower unit with sufficient air windows.

A. Permanent Magnet (PM) Motor

The Blower shall be driven with Permanent Magnet motor. The rotor of the motor has built-in permanent magnet, the power is required only to rotate the shaft. With the rotor being specifically designed to rotate at high speed, the size of the rotor is small. Rotor shall be of titanium & inconel alloy is lighter in weight. Because of these two factors the twisting torque is comparatively very small. The high electric grade material & high rotating speed produce less heat & hence cooling energy required is PM Motor shall be synchronous motor, which has no slip & hence power factor shall be high. The efficiency is consistently maintained more than 95% from full load to partial load conditions. The PM motor is entirely air cooled and capable of a wide range of operating speed. Integrated variable speed drive ensuring starting current of the PMS motor to be less than 10% of the full load current. Current (Ampere) based active control should be used to enable high rise-to-surge.

B. Frequency Inverter

The frequency inverter, DC choke and RFI filter are standard and integrated in the Turbo Blower package. Other types of harmonic filters shall be supplied as per site conditions.

C. Air Foil Bearings

Air bearings shall not come in any physical contacts when shaft is in motion, which doesn't require any lubricant. The Air Foil bearings are of aerodynamic bearings. At standstill (idle mode) the shaft sits on a foil tightened by springs. During operation, due to shaft rotation a cushion of air is generated between the foil and shaft which maintains the shaft in suspension without any need for an external source of compressed air. This increases energy efficiency. The bearings are not lubricated, and the system is absolutely oil-free.

D. Impeller & Casing

The impeller is directly mounted on the shaft of the motor. The impeller is made up of machined cast stainless steel having high structural strength /Aluminum alloy material. The profile is backward leaning to provide larger flow capacity, wide operating flow range & high efficiency.

The impeller alone is first dynamically balanced & again dynamically balanced together after mounting on the shaft. The spiral casing and the blower bell mouth are made of cast aluminum, while the discharge connection is made from Stainless steel.

E. HMI Display

HMI display indicates the Discharge Pressure, Inlet Temperature, Discharge Temperature, Flow Rate, Power consumed, Speed and the across the inlet filters. It shall also displays the performance curve with the actual operating point in it. HMI Touch Screen Graphical Display with on-line performance curve showing Pressure v/s Flow, Operating Point.

HMI should provide on-line display of instantaneous values & trending of following parameters: Pressure Drop across Suction Filters, Suction Air Temperature, Discharge Air Temperature, Discharge Air Pressure, Input Power & Dissolved Oxygen; RPM, Run Hours with facility for MODBUS connectivity to SCADA to display these parameters. Facility for remote control of pressure, flow, power, D.O. parameters shall also be provided. Integrated Mass Flow Meter for instantaneous on-line flow measurement with +/- 1% accuracy.

The following operation mode can be selected from HMI.

a. Constant Current

b. Constant Pressure

c. Constant Volumetric Flow

d. Constant Oxygen (Dissolved Oxygen Control)

F. Acoustical Enclosure

(a) Provide a factory assembled acoustical enclosure around the entire blower. Disassemble the enclosure as necessary for shipment. Provide either removable or hinged doors for access to all blower parts and components for servicing and maintenance. Size access panels to allow easy access by a single operator. Hinges, fasteners and appurtenances shall be stainless steel. Provide clear, transparent Lexan or plastic windows to visually observe gauges. Installation of insect repellent net at the louvers.

(b) Mount an auxiliary exhaust fan and thermostat on the acoustical enclosure to provide air circulation after blower shutdown or when the temperature inside the enclosure exceeds 40ºC.

(c) The free field A-weighted sound pressure level measured in four quadrants at 1.86 metre distance from the enclosure shall average 85 dBA, or less. Measure with a Type 1 instrument suited for checking compliance with Environmental and Occupational Noise Rating Recommendations.

All the accessories shall be complied as per specification mentioned in Centrifugal single stage blower.

Material of Construction:

Si.no.	Description	Material of Construction
a	Blower Housing, Motor Housing	High Strength Aluminium alloy material
b	Impeller	Stainless steel having high structural strength /Aluminum alloy material
c	Shaft	Alloy steel with Permanent magnets/Titanium
d	Base plate	MS Profiled steel
e	Inlet filter, silencer casing	Hot Dip Galvanised Steel Sheet
f	Acoustic enclosure	Al-Zn coated steel, insulated with glass wool
g	Blow-off silencer and motor cooling silencer	Hot Dip Galvanised Steel Sheet
i	Inlet cone extension	Hot Dip Galvanised Steel Sheet
j	Coupling	Alloy Steel
k	Air Foil/Magnetic Bearing Body, Cooling Fan	High Strength Aluminium alloy material
l	All connecting accessories and anchor bolts	AISI 316

8.18.9 Centrifugal single stage Blower:

a) The blower shall be of single-stage centrifugal and shall be designed integral type. The flow rate should be adjustable by controlling the rotation speed with frequency converter according to the inlet temperature and differential pressure to ensure the optimal power consumption. Regulation should be possible in the range of 100-50% of the specified design flows at all project design temperatures and at design pressures.

b) The regulation should be fully automated and contain a program for continuous optimization of blower efficiency with respect to changes in inlet temperature, differential pressure and required flow.

c) The pressure grade of the blower casing shall be minimum PN10. The casing shall be cast and bolted together and allow the impeller to be removed with the casing in situ.

d) The impeller shall be open radial flow type (with backward leaning) and made of aluminium alloy, all surface of the vanes should be finish machining.

e) High frequency, variable rotation speed and air-cooling motor should be adopted. The impeller and cooling fan should be directly connected with the motor shaft.

f) The motor shall be equipped with magnetic bearings (If required), which should have the characteristic of magnetic suspension and continuous variable rotation speed. The motor should be installed at a frame with flexible fastening devices.

g) Two radial magnetic bearings and one axial magnetic bearing shall be orientated accurately via the active-bearing controller controlling the rotor. The active bearing controller shall be powered by one DC and one 3 phase AC input. The service life of all bearings should be more than 100000 hours.

h) Appropriate cooling arrangement shall be provided at the blower discharge line so as to bring down the outlet air temperature within tolerable limits, so as to safeguard the life of fine bubble diffusers and satisfactory performance of the same. This cooling arrangement is mandatory with all types of Blowers.

i) The local control cabinet should be equipped with display screen and keypad unit. The running state of the blower should be able to monitor at real time. The displayed data at least include the following:
   - Actual flow (%)
   - Running time (hour)
   - Running time (day)
   - MWh counter
   - Differential pressure
   - Reference flow (%)
   - Model of the blower
   - Power frequency of the motor (Hz)
   - Current (A)
   - Transition temperature
   - Motor temperature

j) When operating, if the control system finds fault, the blower will give an alarm automatically or stop and the fault code will be displayed at the control cabinet. All signals can be transferred to the control centre of the plant.

k) The blower should have the following protection functions (but not limited to):

- Over voltage of the main power supply
- Under voltage of the main power supply
- I-phase fault
- Over voltage/Under voltage of the auxiliary power supply
- Inlet and outlet air pipe blocking
- Air temperature is higher than the specified limited temperature
- Cooling air temperature is high than the specified limited temperature.

Accessories

a) Inlet filter and silencer:

Each blower shall be provided with an inlet filter/silencer mounted directly on the inlet of the Blower via a flexible connection. Such mounting is for the purpose of reducing pressure drop across the inlet appurtenances and of minimizing noise from pipes. Filter/silencer housing shall consist of stainless-steel plate and acoustical sound-deadening material on the inside. Installation of insect repellent net at the louvers.

Filters shall be removable through easily accessible doors and have very high removal efficiency and shall be sized for maximum face of velocity of 2 m/sec at peak air flow.

b) Discharge Flex Connector:

Each blower shall be provided with discharge expansion Bellows joint of SS316. The expansion joint shall alleviate stress caused by thermal expansion and contraction in the piping system. The expansion joints shall be capable of withstanding the pressure under all operating conditions and shall be rated for temperatures up to 160°C.

c) Discharge Cone Diffuser Silencer:

Each blower shall be supplied with a combined discharge cone diffuser-silencer to increase the discharge from the blower outlet to the discharge pipe, thus reducing the air velocity to max. 16 m/sec. The length of the discharge cone shall be aerodynamically designed in order to recover dynamic pressure head and minimize discharge turbulence. The discharge cone shall be constructed of stainless steel plate and acoustical sound-deadening material on the inside, with flanges, and be equipped with a stud for a possible measuring device.

d) Blow-off (Bypass) Valve:

Each blower shall be provided with a blow-off valve to allow unloaded start-up and unloaded stop. The valve operator shall be motorized, equipped with open/closed limit switches, and shall be suitable for air service at 200°C operating temperature. Controls for the valve shall be mounted in each local blower control cabinet with indicating light.

e) Blow-off silencer:

Blow-off silencer shall be provided for each blower and mounted on the discharge by-pass line. The blow-off valve silencer shall be constructed of stainless steel and contain sound absorption material encased in an outer shell. The silencer shall have one sleeve inlet connection for mounting onto the end of the bypass line.

f) Discharge check valve (Back-flow Barrier):

Each blower shall be provided with one discharge check valve flange ends located in the discharge side pipe work, spring loaded butterfly design for mounting between flanges according BS EN 1092-1/BS: 4504. The pressure losses of the fully open valve must not exceed 1.0 kPa. The valves shall be rated for temperatures up to 160°C.

g) Noise Protection Cover:

The blower and motor should be covered with one Acoustic cover, which should be equipped with electric cooling ventilator.

h) Base plate and anchor bolts:

Each blower unit shall be furnished with a frame of adequate size to support the blower, motor, magnetic bearing controller frequency converter, control cabinet and other accessories. The base plate shall be constructed of fabricated steel, provided with lifting lugs and of sufficient rigidity to permit lifting by a fork-lift, with all equipment mounted, without distortion or other damage to the base plate or to components parts of the machinery.

Material of Construction:

Si. No.	**Description**	**Material of Construction**
a	Blower Housing & Gear Box	CI IS 210 Gr. FG 260
b	Impeller	Stainless steel having high structural strength /Aluminium alloy material
c	Shaft	Carbon Steel (High Tensile) EN 19
d	Base plate	MS Profiled steel
e	Inlet filter, silencer casing	Hot Dip Galvanised Steel Sheet
f	Acoustic enclosure	Al-Zn coated steel, insulated with glass wool
g	Blow-off silencer and motor cooling silencer	Hot Dip Galvanised Steel Sheet
i	Inlet cone extension	Hot Dip Galvanised Steel Sheet
j	Coupling	Alloy Steel
k	Air Foil/Magnetic Bearing Body, Cooling Fan	High Strength Aluminium alloy material
l	All connecting accessories and	AISI 316

Si. No.	**Description**	**Material of Construction**
	anchor bolts	
m	Base plate	MS Profiled steel

Control

The control system of the blower should be well connected with the control system of the whole plant. All the real time monitor and protection function shall connect with the control software; the remote control shall be carried out with 4-20 mA or network.

Local control panel and control cabinet shall be combined, that include display screen and keypad, main switch and lock stop push button. The blower operation shall be controlled by the main running switch and keypad.

Performance Guarantee:

The Performance of the compressor shall be guaranteed according to the requested project design values subject allowed tolerances on Flow & Pressure: +/- 0%, and Power: 2%.

Compressor or any portion thereof is liable for rejection, if it fails to give any of the guaranteed performance parameters.

8.18.10 Submersible Mixer

A submersible mixer shall be used for mixing aerobic tank and anoxic tank in order maintain the oxygen Free State condition. An underwater mixer reduces stirring efficiency and overloads when the amount of tangled impurities in the sewage increases with the propeller. If the amount of tangled impurities in the sewage increases with the propeller, the mixing efficiency decreases and overload operation occurs. When the current values increases, it is necessary to remove impurities.

(a) The submersible mixer shall be installed in the specified plant areas, and they shall be capable of providing a velocity gradient in the range of 500 to 1000 mm/sec. Select a model that can mix sewage and sludge efficiently and uniformly. The mixers and power supply cables should have excellent water tightness and abrasion resistance.

(b) The mixer shall have a self-cleaning propeller optimized for effective mixing and vibration-free running, and required power shall be at least 10Watt/m^3 of tank volume.

(c) The mixer shall be driven by a submersible high efficiency 3 phase motors IP 68 Class F/H. Motor shaft and rotor shall be dynamically balanced.

(d) Bearings shall be lubricated-for-life with a calculated life of more than 100,000 operating hours.

(e) Power supply cable shall be secured such that it is not affected by the mixing flow, cutting with a stirring propeller or deflection.

(f) The mixers shall have the flexibility to be located at different depths and thereby avoiding dead zones. And fixing of the mixer at the bottom of the tanks it should not affect the sediment and mixing flow.

(g) The mixer shall be provided with the following :

(1) Lifting frame with a winch which can be dismantled, free standing with adjustable boom length.
(2) Mounting socket for free standing hoist suitable for wall mounting.
(3) Guide for floor fixing components and support brackets for wall mounting.
(4) Stainless steel (SS316) rope for raising and lowering the mixer.
(5) Rope block for holding the stainless steel 316 rope where the lighting frame is used in different locations.
(6) Support rope for reliable support and guidance of power supply cable.
(7) Support clamps and hooks to support the power supply cable in such a manner that it is not under strain.
(8) The propeller, and motor housing, guide pipe, support brackets and all fasteners shall be of SS 316. The propeller shaft shall be of SS 431/SS 420.The Lifting winch & Davit shall be of Stainless Steel 316 construction.

8.18.11 Rotary Air Blowers

(a) Compressor blowers shall be of the rotary tri lobe positive displacement type, each provided with inlet filter and silencer, pressure reducing valve, pressure gauges, pressure relief valve, drain, air flow indicator and acoustic bend or silencer in the delivery branch. Bearing housings and gear boxes shall be separated from the blower housings by air spaces. The units shall be complete with a self-contained oil cooling system for the bearings. The blowers shall be housed inside acoustic enclosure. The noise level shall not exceed 85 dBA at 1 meter from the Blower.

(b) The bearings shall be generously designed to give long operational life. Bearings at the drive end may be oil or grease lubricated. The gears and bearings at the non-drive end shall be oil lubricated. Bearings shall be provided with oil throwers to prevent leakage of oil. The blower shall be arranged for horizontal inlet and vertical outlet, delivery velocity not exceeding 16 m/s and each blower shall be provided with following components but not limited to:

(1) Common base frame for Blower & Motor.
(2) Inlet silencer and filter, with inspect replant net to avoid insect entry.
(3) Discharge Silencer & non-return valve in delivery branch.
(4) Motorised Butterfly valves in both inlet and delivery branches with metal to metal

sealing.

(5) Pressure relief valve or excess pressure safety device.

(6) Bellows SS 304 type couplings on inlet and delivery piping & on suction & delivery silencers.

(7) Acoustics Enclosure.

(8) V-Belt drive arrangement with Belt Guard.

(9) Isolating valves, Pressure reducing valves & Pressure gauges

(10) Air Flow meters, Temperature gauges.

(11) Water trap.

(12) Gravel filter.

(13) Blower piping individual delivery pipe shall be provided dummy flange extension with pipe spool on opposite side of common header to reduce the noise level.

(14) After cooler arrangement for each blower on outlet side.

(c) The interconnecting pipe work shall be flanged to BS EN 1092-1/BS: 4504. A drain cock shall be provided at the lowest point in each delivery pipe work along with reflux valve. Individual stop valves and safety valves shall be provided for each unit.

(d) Blowers shall be driven by squirrel cage motors through a matched V-belt drive. Motors shall be mounted on slide rails mounted on a common bed plate, to facilitate the tensioning of the belts. Blowers shall not run above 1000 rpm and prime movers also.

(e) Each delivery branch shall include a drain at the lowest part and a reflux valve.
Each blower shall contain one inlet air pressure, one discharge air pressure, and one discharge air temperature gauge. The pressure gauges shall be calibrated in kPa absolute and be of the compound type. The gauges shall have circular dials, minimum 100 mm diameter with black figures on white background. Pressure gauges shall be furnished with pulsation damper. Temperature gauges shall be manufactured with standard temperature bulb.

(f) Appropriate after cooling arrangement for each blower shall be provided at the blower discharge line so as to bring down the outlet air temperature within tolerable limits, so as to safeguard the life of fine bubble diffusers and satisfactory performance of the same. This cooling arrangement is mandatory with all types of Blowers after cooler shall be preferably shell and Tube type.

	Description	**Material of Construction**
a	Blower Housing	CI IS 210 Gr. FG 200 or 220
b	Lobes	CI IS 210 Gr. FG 200 or 220
c	Shaft	Carbon Steel (High Tensile) EN 19
d	Base plate	MS fabricated Epoxy Painted
e	Inlet filter, silencer casing	Galvanised Steel
f	Acoustic enclosure	Al-Zn coated steel, insulated with glass wool
g	Blow-off silencer and motor	Galvanised Steel

	Description	**Material of Construction**
	cooling silencer	
i	All connecting accessories and anchor bolts	AISI 316

8.18.12 Acoustical Enclosure

(a) Provide a factory assembled acoustical enclosure around the entire blower. Disassemble the enclosure as necessary for shipment. Provide either removable or hinged doors for access to all blower parts and components for servicing and maintenance. Size access panels to allow easy access by a single operator. Hinges, fasteners, and appurtenances shall be stainless steel.

(b) Provide clear, transparent Lexan or plastic windows to visually observe gauges and lever arms.

(c) Mount an auxiliary exhaust fan and thermostat on the acoustical enclosure to provide air circulation after blower shutdown or when the temperature inside the enclosure exceeds 40^{o}C.

(d) The free field A-weighted sound pressure level measured in four quadrants at 1 metre distance from the enclosure shall average 85 dBA, or less. Measure with a Type 1 instrument suited for checking compliance with Environmental and Occupational Noise Rating Recommendations.

8.18.13 SBR System – General Requirements

(a) General

The vendor/supplier of the SBR system shall be completely responsible for the proper design of their system in full compliance with all requirements of the bid documents. The SBR system shall include but not be limited to: basin influent and other valves and actuators, diffused aeration equipment, Process air blowers, Waste activated sludge (WAS) transfer pumps, mixers/Selector zone with Coarse bubble diffusers, Decanters, and all other ancillary equipment and controls necessary for a fully functioning SBR system.

The SBR process and cycle time design shall incorporate true quiescent batch settling and a dedicated decant/wasting phase. Designs that allow influent flow/filling or include any other feature that compromises true quiescent batch settling during the settling or decant phase will not be permitted.

(b) Mixing and Aeration Performance

The SBR mixers shall be submersible mechanical mixers or by means of Selector zone with Coarse bubble diffusers. SBR mixers shall be designed to ensure complete mixing of the entire basin contents at all operating depths between the minimum and maximum depths, without the introduction of air. The mixing energy and velocities shall be sufficient to ensure complete and uniform solids suspension and dispersion, without any “dead pockets” of low velocities or settling or accumulation of solids.

The aeration system shall be designed to provide adequate oxygen transfer to the contents of each SBR basin during the aeration phase, in accordance with minimum requirements specified elsewhere in these bid documents. Complete mixing and uniform distribution of air throughout the basin shall be achieved. This may be achieved with or without the simultaneous use of mixers during the aeration phase. For mixing-limited aeration systems, i.e., systems where the biological process air requirements at any operating condition are lower than air requirements for complete mixing, upsizing of the aeration system to provide required mixing will not be permitted. Such systems shall be designed to use the mixing and aeration systems together to simultaneously meet the mixing and aeration requirements.

Decanters (For SBR system)

(a) General

SBR decanters shall be floating or electro-mechanically positioned with subsurface withdrawal and a positive solids and scum exclusion mechanism. Each decanter shall be capable of withdrawing decant effluent from 4 to 6 inches beneath the liquid surface, regardless of liquid depth, down to the minimum design operating level. Decanters shall employ positive mechanical type seals or substantially similar mechanisms for excluding solids, scum, and any floatables from the effluent.
Site fabrication of decanters shall not be acceptable.

A telescoping valve shall be provided in each basin for periodic removal of scum and floating material. For electro-mechanically positioned decanters that pass through the surface layer to decant, the decant phase of each cycle shall be preceded by a skimming phase that shall fully and completely remove all scum and floating material from the vicinity of the decanter such that, when the decanter is positioned for decant, no scum is trapped between the decanter's weir and scum baffle.

All wetted components of the decanter assembly shall be constructed of 316L stainless steel including Piping. No effluent boxes or concrete mounting structures internal to the basin will be allowed. The wall pipe and embedment shall be designed to safely accommodate all loads transmitted by the decanter assembly under all operating and maintenance conditions.

All the withdrawal SS 316L Pipes shall be of thickness not less than Schedule 20S above 200 mm and Schedule below 200 mm shall be of Schedule 40S, and all the pipes shall be of Seamless type only.

The decanters shall be designed to mount to an appropriately sized cement mortar lined and coal tar epoxy coated ductile iron flanged pipe embedded in the SBR basin wall.

(b) Decant Flow Control Valve

An appropriately sized electrically operated butterfly flow control valve or through sluice gates & Stop logs shall be provided in the effluent pipe for each decanter to control the decant rate. All effluent flow control valves shall be located outside the walls of the SBR basins. If flows are received through the

channels in such case provision shall be made to isolate each SBR basin using Sluice gates or Stop logs to take of preventive maintenance.

(c) Supports

For floating decanters, a complete support system/structure shall be provided to safely support the entire decanter assembly when the basin is drained. The support system shall be rigidly anchored to the basin floor. All concrete embedded components (such as anchors) of the support system shall be 316L stainless steel. The other components shall be 316L stainless steel.

8.18.14 IFAS (Integrated Fixed film Activated Sludge) Treatment

The Fixed Film Activated Sludge system shall be designed to encourage attached growth of biomass on the fixed media and limit the suspended solids in aeration tanks as per CPHEEO. Addition of this system shall increase the biomass inventory in the aeration tank, through attached growth process. A Knitted fabric with growth surface strips with supporting loops made of flat fabric curtain sheet having density around 0.90g/cm3 is immersed into a basin in which biological growth also takes place in suspension. The media then provides a surface for the growth of attached biomass. Biomass attachment in the media shall not exceed 55 grams per m2 length of active surface area This combination of attached biological growth and suspended biological growth is a more efficient wastewater treatment system because there is an increase in the overall active biomass volume for a given system. Total biomass (Suspended + Attached) in the system shall not exceed greater than 4500 mg/l

IFAS design shall ensure sufficient BOD and TSS removal while encouraging nitrification of ammonia in the aeration tank. The system should be made up of bio-textile sheets aligned in metal cages. The fixed film media needs to be of polypropylene knitted curtains mounted on SS 316 cages. The IFAS Curtain shall be 100% Polypropylene yarns. The clamps and fixing accessories shall be of water-resistant PP.

The fixed IFAS curtain media should be arranged parallel into the direction of flow. There shall be no double wrapping/strings of textile on cages. The fixed film system shall use discreet, parallel textile sheets on the cage. Rigid media shall not be allowed. Bio-textile sheets shall be knitted fabric with growth surface strips. The maximum specific growth surface shall be 25 m2/m2 design. Maximum active surface co-efficient shall be ≤ 0.65.

The systems shall require low maintenance and shall be a high energy efficiency system. It shall not use any suspended media to avoid media loss. Further, the fixed film system shall be provided in conjunction with high efficiency fine bubble diffuser mounted underneath of IFAS cages in aeration tank. The diffusers shall be spread throughout the basin to provide uniform aeration. Coarse bubble aeration shall not be acceptable.

8.18.15.1 Testing of IFAS system

All inspection and testing shall be carried out in accordance with relevant Indian Standard and in absence of IS as per Detail Tender Specification or internationally approved equivalent standard. The strip diffuser system shall have the capability to transfer the specified amount of oxygen at standard conditions, Standard Oxygen Transfer Rate or SOTR at standard conditions (14.7 psia, 20° C, zero dissolved oxygen) at the side water depth and maximum allowed air rate and pressure specified below.

Submit clean water test data from prior tests performed or witnessed by independent test organizations to demonstrate the capacity of the proposed equipment to meet the specified oxygen requirements. Tests shall have been performed in test tanks or process basins and shall be witnessed by an independent third party knowledgeable about clean water test procedures.

8.18.15.2 Diffuser system for IFAS

Fine Bubble Diffuser Detail to be used for IFAS shall be as per the below requirement, only fine bubble PU membrane diffusers shall be acceptable with minimum membrane diffuser to floor coverage area of 8%. Diffusers shall be submerged fine bubble / fine pore, high transfer efficiency, low maintenance, non-buoyant type. Diffusers shall be strip (membrane) type. Material of construction for (entire under water system including accessories shall be of non-corrosive Complete diffuser as a unit shall be assembled at the manufacturing factory level. The grid supports shall be made of SS 304.

8.18.15.3 Type of Diffuser System

A fine bubble diffused aeration system shall be applied to aeration tank for oxygenation. The number of diffuser elements can be varied by the bidder depending on the manufacturer selected, subject to the condition that sufficient design calculations are attached along with it and the manufacturer is a standard one having supplied the diffusers to various wastewater treatment plants of similar nature in the installing country.

8.18.15.4 Diffuser Elements

The diffuser elements shall be membrane type and resistant to such ingredients as hydrocarbons, oil and grease. This shall afford a high oxygen transfer rate coupled with a minimal pressure drop besides permitting simple erection onto the horizontal air manifold.

They shall have minimal coupling / attachments to the air manifold and shall have self-cleaning properties while in action. Flat surfaces facing upwards as membrane surfaces shall only be accepted. The diffuser unit shall be of corrosion resistant material. The membrane diffusers shall permit connection to the air manifolds of circular or square cross section and the entire lot of diffusers shall be

capable of discharging designed flow of air at an average flow (maximum of summer and winter requirement) with the nominal air flow per diffuser per element shall not exceed 80 m3/h/m2 of diffuser surface area when installed in the said aeration tanks.

The diffuser grid shall be of fixed type. The headers onto which the diffusers are fixed shall be of standard Imported PE/PVC/UPVC pipe sections of suitable inner bore and shape with custom fixtures of the diffuser elements as directed by the membrane manufacturers. Alternative pipe materials shall be acceptable provided the same are a mandatory part of the diffuser supplier and the sub-headers have enough counterweight or alternative arrangement to surmount any buoyancy lift from the floor during air charging.

The diffusers shall be fixed to bioreactor floor, Fine Bubble Diffused Aeration membrane diffusers with a maximum flux through the diffusers not exceeding 80 m3/m2 membrane area. The air from the blowers which shall have high temperature and should be cooled suitably to avoid damaging the diffuser membranes.

The material of diffuser and associated fixtures shall be:
Diffusers Membranes -PU Membranes
Diffusers Membranes Support -Engineering plastics Non-Corrosive material
Under water Air Piping to diffusers -UPVC/PE
Air downers to underwater pipe - UPVC/PE
The in-tank diffuser piping shall be sized for a velocity less than 21 m/sec.

8.18.15.5 Testing for Diffuser system

All inspection and testing shall be carried out in accordance with relevant Indian Standard and in absence of IS as per Detail Tender Specification or internationally approved equivalent standard at Manufacturer's Work.

8.18.15.6 Air Piping to Diffusers

SS Air headers are to be provided to avoid corrosion and the consequent damage to the fine bubble diffusers. System should allow acid injection and relaxation to ensure proper functioning of fine bubble diffusers.

8.18.15.7 Chemical Considerations

Provision to dose Alum (For P removal) shall be considered based on Inlet Parameters. Provision to dose External carbon to be considered if BOD: TKN ratio is to be less than 4.

8.18.15 MBBR Treatment Technology

A. GENERAL

The Moving Bed Bio Reactor (MBBR) process allows carrier elements to move about freely within an aerobic reactor. Sieve assemblies shall be used to retain the carrier elements within each reactor. Wastewater is fed to the MBBR reactor on a continuous basis. A portion of settled sludge becomes WAS while the remaining sludge is pumped back to the Anaerobic zone of the plant as RAS.

B. Biofilm Carrier Elements

Material is an extruded, Virgin high-density polyethylene. The density of the biomedia shall be nominal of 0.98 and a minimum of 0.96. Minimum effective surface area for biofilm carrier elements in bulk for biomass growth is 500 m^2/m^3. The media needs to be of an extruded type and not injection molded. The biofilm carrier elements shall have a maximum diameter of 20 mm with a Nominal height of 5 to 10 mm. The system supplier shall provide carrier elements.

C. Aeration System for media

The entire aeration system shall be a full floor coverage device. Each aeration grid shall comprise of central manifold of 316 SS Schedule 10 thickness equipped with diffuser laterals of 316 SS (seamless) Schedule 10 thickness. The laterals shall be mounted on both sides of the center manifold, equally spaced along the length of the manifold. The laterals will have 4 mm holes drilled at equally spaced intervals. The aeration manifold shall be designed to provide uniform distribution of air to each lateral and allow for a turn down of 50% of the design airflow without loss of equal distribution of air to each lateral.

D. Sieve Assemblies

A total of one (1) sieve assembly shall be provided in the reactor. Individual sieves shall be constructed of stainless steel 316 perforated plate and have a minimum of 55% open area. The openings within the sieve assemblies shall be a minimum of 12 mm diameter and provide a minimum of 30 m2 area per basin for maintaining a maximum headloss of 5 cm through each reactor at peak hydraulic flows of surface. Sieves shall be stiffened at specific locations as required based on sieve length using solid stainless-steel material. The system supplier shall provide the required sieve assemblies.

E. Supports

The system supplier shall provide all necessary supports for the aeration manifold and sieve assemblies. All submerged supports and connection hardware shall be constructed of stainless steel, Type 316.

MEDIA, PIPING, AND APPURTENANCES

Components of the moving bed biofilm reactor treatment system shall be fabricated of the following:

Biomedia	Virgin HDPE – Extruded
Media Shape	Cylindrical with internal fins/spokes
Aeration Grid	Stainless Steel, Type 316
Sieve Assembly	Stainless Steel, Type 316
Supports	Stainless Steel, Type 316
Bolts, Nuts & Fasteners	Stainless Steel, Grade 316
Washers, Flat	Stainless Steel, Grade 316

All fasteners and anchor bolts shall be 316 stainless steel unless otherwise indicated. Anchor bolts shall be provided for mounting the aeration system and sieve assemblies.

The contractor should provide detailed bioreactor calculation including but not limited to bioreactor volume, media volume, basis for adopting nitrification rate on moving carrier media and on MLSS, air requirement, and nitrate and sludge recycle rate.

8.18.16 Ultra Filtration System (Submerged/ Pressurized)

Ultrafiltration system is provided after the disc filtration system unit, and bidder can propose either Submerged or Pressurized ultrafiltration system based on the suitability of site and considering ease of operation and maintenance of the Ultrafiltration units. The ultrafiltration Plant output shall be minimum 50% of WwTP Plant capacity (20 Hours of Operation) and all the process units and equipments shall be designed to match the output capacity of the plant. For Particular requirements, refer in Volume 2, Section 7 Part 5 of the bid document.

The Ultrafiltration treatment for **Each battery/ module Skid arrangement** shall include but not limited to the following items listed below.

a) Ultrafiltration module with rack suitable for Pressurized membrane **or** Ultrafiltration modules for Submerged membrane with housing with complete inlet and outlet Piping, Valves etc. arrangement.

b) Ultrafiltration system shall have Positive Displacement Rotary Lobe Blower of suitable capacity of minimum 2 Nos. (1W+1S).

c) Ultrafiltration Feed Pumping arrangement with VFD operation of suitable capacity of minimum 2 Nos. (1W+1S) either Submersible or Horizontal centrifugal Pump sets.

d) SS 316 Basket Strainer or Pre filters before feeding it to the UF membranes. The Contractor shall provide Self Cleaning strainers to remove particles and debris, such as drill shavings, present in the secondary effluent that could be expected to damage the membranes used in the UF process. The screening properties of the strainer shall be based on the requirements of the UF membrane process. The self-cleaning filters shall be automatic with a self-cleaning backwash mechanism.

e) Permeate Transfer Pumps or Filtrate transfer with VFD operation with Pumping arrangement of suitable capacity of minimum 2 Nos. (1W+1S) Horizontal centrifugal Pump sets.

f) Backwash Transfer Pumping arrangement of suitable capacity of minimum 2 Nos. (1W+1S) either Submersible or Horizontal centrifugal Pump sets.

g) Neutralization Pumping arrangement of suitable capacity of minimum 2 Nos. (1W+1S) either Submersible or Horizontal centrifugal Pump sets.

h) CIP Clear water Transfer Pumping arrangement of suitable capacity of minimum 2 Nos. (1W+1S) Horizontal centrifugal Pump sets. The contractor shall maintain CIP Tank with online level measuring sensor for continuous measurement and control through PLC and HMI.

i) Common units for all battery/ module Skid arrangement such as Sodium Hypochlorite dosing system, Citric acid, Hydrochloric Acid, Sulphuric Acid and any other acid shall be as per process requirement suggested by the vendor. Each dosing unit shall have minimum 3 nos. (2W+1S) chemical dosing/metering pump sets, Dosing Tank of minimum 2 Nos. (1W+1S) if any agitators required bidder shall be included in the design.

j) Air compressor system with Rotary screw or Reciprocating type of minimum 2 Nos. (1W+1S) along with Piping arrangement.

k) Piping: All the liquid piping shall be SS 316 material, Process Air shall be SS 304 material and chemicals usage shall be CPVC only.

l) All the Valves shall be provided based the Process liquid which will be handled and as specified in the bid document only.

m) Properly sized Drain Trenches shall be provided in the Ultrafiltration Building for routing out any leakage from the building.

n) All the Electrical equipment such as MCC Panels and Instrumentation control panels with all necessary interlocks shall be provided for auto operation of the UF Plant. MCC Panel and control Panel shall be of IP 55 Protection. Ventilation/ Cooling arrangement shall be provided in Control Room with Split Case AC units suitable for total Heat dissipation from the Panels and Occupancy by O&M Personals. All MCC & Control Panels shall be suitable for top entry of cables.

o) The control Panel shall be embedded with the PLC and Panel mounted HMI Touch Screen (10 inch size) and also PLC data shall be interfaced with Plant Main PLC/ SCADA system by using Hard wired communication for continuous monitoring and control from main PLC/ SCADA. Please refer system Architecture drawing of Volume 4 for system integration purpose.

p) The UF Plant shall have safety features like Emergency shut down and fail-safe mechanism in abnormal condition such as Power failure mode, Overflow or Underflow condition at Ultra Filtration feed before membrane skid with cut off operation (As safety interlock), Membrane integrity Breach condition and High chlorine dosing condition with sensor indicating alarms.

q) Noise Level within building shall be limited to 85 dBA with all the units/Equipments in working condition (Such as Blower, Feed Pump, Backwash Pump and Dosing system).

r) The instruments such as rota meters for feed, reject and permeate and pressure indicators for feed, reject and permeate shall be located on the SUF skid such that all instrument have easy access and good visibility.

s) Lifting Arrangement shall be considered based on the heaviest equipment which will be lifted from the UF building.

t) Ventilation with minimum 10 to 12 air changes/hour shall be considered and fire safety equipments shall be provided in the area.

u) Safety Precautions sign board shall be provided based on the acid usage in the UF plant.

v) For submerged membrane tanks, shall be provided with suitable sized Sluice gate at inlet and outlet points.

w) Proper illumination shall be provided for the UF building/Room.

x) All the cable shall be provided with proper closed cable tray and conduits.

y) For Submerged membrane proper inspection platform with Electric hoist arrangement shall be provided for ease of operation and maintenance.

z) Minimum spares shall be maintained at the plant premises to have continuous supply of treated water minimum output of the plant.

A. Minimum Process Performance Monitoring Instruments

The treatment facility shall have the following process performance monitoring instrumentation as a minimum:

- Additional instruments for refurbished WwTP's for continuous online monitoring – Raw
- Sewage: Flow, Pressure, Turbidity, Temperature, TOC, pH, Conductivity Treated.
- Secondary Sewage: Flow, Turbidity, Temperature, TOC, Residual Chlorine, Conductivity,
- pH Value.
- Secondary Treated Sewage Transfer: Flow, Pressure, Residual Chlorine.
- UF Feed Common header: Turbidity, Temperature, TOC, Residual Chlorine, Conductivity,
- Free Oil.
- Individual UF Train Feed: Pressure, Flow.
- Individual UF Train Permeate: Turbidity, Pressure, membra ne flux (calculated), TMP.

(calculated)

- Backwash Inlet: Pressure, Flow.
- CIP Inlet: pH, Pressure, Flow.
- UF Air Blower: Flow, Pressure.
- Self-Cleaning Filter: Differential Pressure
- All Storage Tanks: Level with redundancy
- All dosing Tanks: Level
- All pump discharge: Pressure
- UF Reject Transfer: Pressure, Flow
- Chemical Unloading pump: Pressure, Flow
- Neutralized Chemicals: pH, Chlorine, Pressure, Flow
- Tertiary Treated Sewage Transfer: Flow, Pressure, Turbidity. Residual Chlorine
- Compressed Air: Pressure, Dew
- Utility and Potable Water: Pressure, Flow

The type of instruments for TTP shall be as indicated in the P&ID and in the instrumentation section. The Contractor shall maintain the failsafe mechanism with redundancy features of field instruments for critical parameters like TMP, Flow, pH and residual chlorine at inlet and Outlet.

B. Chemical Storage and Dosing for TTP

The Contractor shall equip the Plant with centralized chemical storage area(s). The capacity of each chemical should have a volume which is equivalent to 14 days of full load operation for bulk storage tanks and 7 days for small dosing tanks. The chemical storage area shall be either indoor or sheltered with a roof. The chemical storage tanks shall be bunded (each chemical separately) to ensure that an accidental leakage is retained within the bund. The bund shall be of sufficient volume to contain 110% of the entire contents of the contained tanks.

C. Submerged Ultrafiltration (SUF)

General

- Ultrafiltration (SUF) with submerged membrane modules can be used for various water purification applications.
  - Tertiary effluent treatment in wastewater treatment plants (WwTP).

- The material for membranes used shall be Braided / reinforced PVDF. The module size, its pore size, operating and back flush flux rate, temperature stability, solvent resistance, bacteria inhibition and resistance to fouling of the membrane shall be suitable to cater to the required duty.

- Adequate space shall be provided on the feed and reject side of the SUF skid to ensure easy loading and unloading of the SUF membranes.

- All the components of the chemical cleaning system shall be able to withstand extreme pH and temperatures up to 45°C.

D. Working Principle of Submerged UF Process:

- Within a SUF process the submerged membrane modules are typically installed in one or more separate membrane tank(s) downstream of the former process steps. Mechanical pretreatment is required to remove fibrous material, large particles and other materials that may be harmful to the membrane from the SUF system. The required type of pretreatment depends on the kind of the water source upfront.

- After mechanical pretreatment, the wastewater is fed to the membrane tanks where the water is separated from the solids by the SUF membranes. The liquid is typically fed below the submerged membrane modules.

- The filtered water (or permeate) passes through the membranes by means of a permeate pump which applies a vacuum on the interior of the membrane fiber. The concentrate is retained in the membrane tank. In case of tertiary effluent filtration, it is typically recycled back upfront of the biological process

to remove the solids with the surplus sludge. In case of surface water treatment, the concentrate is typically returned to the water body (depending on local rules and regulations).

- The filtration tanks (also called trains or filtration lines) are typically designed with some degree of redundancy to allow the system to operate and treat the required liquid flow rate when part of the membrane area is down for cleaning or maintenance.

E. Operating Modes for Submerged Membranes in a UF System

- For a hollow fiber membrane configuration, the membrane portion of the SUF system has two basic operating modes: production and chemical cleaning. During production mode, feed water flows from the upstream treatment steps to the membrane tanks. Depending on the application, concentrate may be removed from the membrane tank either continuously (feed & bleed process) or dumped in regular intervals (dead-end or batch mode).

- Depending on the system layout, the UF filtration system may be designed with pumped feed, or gravity feed. As water is pulled through the membranes as permeate, solids accumulate on the surface of the fiber bundles causing an increase in differential pressure across the membrane surface. Several flux maintenance techniques are used in a submerged hollow fiber membrane configuration.

F. Air Scour

- Mechanical removal of solids from the membrane surface is accomplished through the use of air scour which is applied to scrub the outside surface of the membrane and removal with the concentrate.

G. Permeate Backwash/Flush

- With Permeate Backwash/Flush, the permeate flow is reversed through the membranes is used to control the solids concentration at the membrane surface to help maintain membrane filtration system performance and increase the time between membrane cleaning cycles.

H. Chemical Cleaning

- Over time however, materials will adhere onto the surface of the membrane which cannot be removed by a mechanical means (i.e. backflush or air scour). Accumulated substances, such as biofilm, scale, or other deposits on the membrane surface, require a chemical cleaning. Cleaning is discussed in greater detail in the next section.

- Permeate pumps are used to extract the treated water through the membrane. The same permeate extraction system is also designed to push permeate back into the membranes during backflush cycle. The two most common permeate extraction systems are based on a reversible pump and on a centrifugal pump.

- Common chemicals such as sodium hypochlorite, citric acid and any other mineral acid are used to chemically clean the membranes.

- The type of chemicals used depends on the nature of the foulant and the membrane materials of construction. There are two types of chemicals cleans utilized in system - Maintenance Clean (MC) and Recovery Clean (RC). MCs are shorter, regularly scheduled and are employed to maintain the membrane permeability.

- For MCs and RCs, the tanks are drained and re-filled with cleaner chemicals solution. MCs are realized with lower chemical concentrations and lower contact time. RCs are more intensive cleans that are used to restore the membrane permeability. RCs are typically performed typically once per 1 - 2 months and additionally when the system experiences upset conditions.

- Maintenance clean is normally fully automated while RC may be semi-automatic.

- Two or three chemical dosing systems are typically incorporated in the design of the filtration section of the SUF system, to deliver sodium hypochlorite and citric acid / mineral acid for the in-situ membrane cleaning cycles.

- The SUF product is a supported hollow fiber membrane operating with an outside-in flow path. The solids remain on the outside of the fiber and the clean permeate passes through the membrane and collects in the internal bore of the fiber. Vacuum is applied to the inside of the fiber to pull the clean water through the membrane wall.

- The SUF membrane is a hollow fiber membrane cast on a braided support and has been specifically designed to address the aggressive nature of the wastewater treatment environment in which it operates. The braided support results in a high mechanical strength composite membrane, making it virtually impossible for individual fibers to tear, break or delaminate during normal operation.

- The consumption of cleaning chemicals strongly depends on the specific parameters of each plant and on the operational conditions. It will also depend on the hardness and alkalinity of the water source, which will determine the required schedule of acid MC and RC. Membrane cleaning procedures are typically optimized during the first year of operation of the plant.

- Comprised of a Braided / Reinforced PVDF formulation, the distinctive morphology of the membrane provides superior performance. With high porosity and a nominal pore size of 0.03 micron, the membrane resists fouling while providing high sustainable flux rates. As a result, it responds better to cleaning regimens yielding higher permeability recoveries, lower trans-membrane pressures (TMP) during filtration, and extended life potential. A summary of membrane properties and common operating parameters appears as per below table.

Technical Particular	**Parameters**
Membrane technology	Ultrafiltration (SUF)
Membrane Type	Braided or Reinforced Hollow Fiber
Braid / reinforced material	Polyester or if any as per vendor recommendation
Feed Temperature	20 to 38 degree C
Membrane material	PVDF
Nominal pore size	0.03 microns (maximum)
Driving force	Vacuum
Permeate flow direction	Out to-In
Nominal fiber Diameter (OD)	1.2 to 2.6 mm
pH Operating range	2.0 – 10.5
Operating temperature range	41 - 104 °F / 5 - 40 °C
Maximum backflush transmembrane pressure	9.0 psi / 0.6 bar
Maximum filtration transmembrane pressure	9.0 psi / 0.6 bar
Fiber Strength	> 600 N
Minimum Operating life for Membrane	10 years
Specific Energy Consumption kWh/m³ (Treated)	Vendor to Provide details
Individual Modules are accessible for any replacement/future modules additions	Vendor to Provide details, If Yes, provide details of provisions for Spare modules.

I. Single Header Design

- Some SUF membrane modules have difficulty dealing with fibrous material, which tends to clog vulnerable areas in the module leading to operating and maintenance problems. The clogging problem is common and noticeable in double header hollow fiber products at the top header, where hair and fibers that passed through the system pretreatment are forced into the potted membrane bundle by the aeration system.

- Sludging at the bottom header often occurs in some products because there is little or no air scour to remove sludge from the base potting area. In addition, membranes that are potted at both ends or held around the edges often require over sizing to allow for expansion, contraction and to prevent breakage during manufacturing. This practice causes strain under normal operating conditions particularly during aeration, which often results in membrane integrity failure and delamination.

- The SUF product consists of bundles of hollow fiber membranes potted only at the lower end of each bundle. The non-potted ends of the fibers (at the top of the bundle) are individually sealed and move freely in the liquid. The lower end of the upright membrane bundle is fixed in a foot element, with a central air nozzle to inject air into the center of the membrane bundle, the place with the greatest potential for solid accumulation.

- Single header product with central aeration provides agitation from the bottom of the membrane bundle and free-floating fiber tips, allowing the fibrous materials to float free of the module.
  In this configuration provides the following advantages:
  - Reduces clogging and sludging.
  - Allows higher fluxes.
  - Allows for intermittent aeration and lower aeration rates.

J. Central Aeration System

- The central aeration system allows maximum utilization of the air that is delivered into the center of each membrane bundle. This configuration forces the air to expand the bundle and move from the inside to the outside of the membrane fibers.

- This design exposes the entire fiber length to air scouring with the air applied directly to the area of the membrane that is most susceptible to solids accumulation (i.e. the center of the bundle). Other membrane systems, where the air is applied around or below the membrane permeate header, cannot offer this level of efficiency.

- The sheer force of the injected air scours the entire length of the membrane surface removing deposits from the membrane. Fibrous substances do not clog the top of the bundle since it is not potted, and the potentially harmful material is allowed to pass freely through this area. Module sludging and clogging is largely prevented with the central air scour nozzle and free-floating membrane tip design utilized by module.

K. PVDF Membrane with Braided

- The membrane fiber features a Braided PVDF membrane formulation cast on polyester support braid. The PVDF membrane exhibits a tight pore size distribution with a nominal pore size of 0.03

micron. This membrane formulation permits the membrane to operate at high flux rates with low fouling characteristics. In addition, the support braid is virtually unbreakable, leading to a robust product with a long serviceable membrane life.

- The fiber is braided, allowing it to go through intensive backwash cycles that are critical to maintain high flux rates and overcome sludging events. These backflush cycles, combined with the single header configuration and central aeration, allow the product to maintain high peak flux rates in high solids SUF applications up to 2000 mg/l in the tank.

- The module terminology indicates the single header design and the membrane area for a fully installed module.

- The centrally aerated membrane bundles form the basis of the module. The fiber supports prevent the membrane fibers from bending, particularly during installation or removal of the module.

- The integrated header on the bottom of each row contains two separate chambers - one for air distribution and the other for permeate extraction and backflush. The permeate chamber is attached to a lift pipe that directs the filtrate upwards where it is led into a center collection header. A similar arrangement is used for the air distribution.

- The individual membrane rows, two permeate collection headers and the two air distribution headers, are mounted on a self-supporting module frame. The membrane module is fitted with lateral permeate connections and two air distribution pipes. Furthermore, plates are mounted on the outside of the module that serve to significantly reduce clogging and enhance the flow pattern through the module.

L. Aeration Requirements

- The membranes operate either with a cyclical air scour delivery, requiring aeration only during a low percentage of the time or only during the backwash sequence. This depends on the water source, the type of solids to be removed and the concentration of these solids.

- This aeration regime allows the membrane to offer one of the lowest air scour requirements in the industry as many other membrane systems require higher air scour delivery rates while operating in similar applications.

Technical Particular	**Parameters**	
Length of Membrane Module	mm	As per Vendor Recommendation
Width of Membrane Module	mm	As per Vendor Recommendation
Height of Membrane Module	mm	As per Vendor Recommendation
Dry Weight of Membrane Module	Kg	As per Vendor Recommendation
Maximum No. of Membrane Rows which can be installed per Module	No.	As per Vendor Recommendation
Filtration Area of each Row	m2	As per Vendor Recommendation
Filtration Area of Module	m2	As per Vendor Recommendation
Membrane Fiber Chemistry		PVDF (Braided Fiber or Hollow Fiber (Reinforced)
Fiber Support Chemistry		Polyester or if any other as per Vendor Recommendation
Membrane Module Assembly		Single Header
Membrane Module Frame or Rack Material		SS 316
Spare space for module per Train		10%
Nominal fiber Diameter (OD)	mm	1.2 to 2.6 mm
Flow Direction		Out to– In
Nominal Pore Size	micron	0.03 microns (maximum)
Feed Temperature		20 to 38 degree C
Housing Material and Permeate Collection Tub Material		UPVC ABS, PVC, PE Manifold
Permeate Connection Type		Grooved Coupling of suitable size
Air Connection Type		Grooved Coupling of suitable size
Maximum Filtration Transmembrane Pressure	Bar	0.6
Maximum Back Wash/ flush Transmembrane Pressure	Bar	0.6
Acceptable Range of Cleaning pH values		2.0 – 10.5
Lifetime Total Chlorine Exposure	ppm-hrs.	5,00,000
Maximum chlorine Concentration	mg/l	1,000 (as $NaOCl)^3$
Minimum Operating life for Membrane	Years	10

Technical Particular	Parameters	
Specific Energy Consumption	kWh/m3 (Treated)	Vendor to Provide details
Individual Modules are accessible for any replacement/future modules additions	Yes/No	Vendor to Provide details, If Yes, provide details of provisions for Spare modules.

8.19 Scum removal equipment- Common for all type Technologies

In the biological reactors, scum may be generated due to the BOD-SS quality of the influent sewerage.

The occurrence of scum indicates the status of sewage treatment maintenance and management and may lead to deterioration of the quality of discharged sewage water.
If scum is caused by actinomycetes, suspended solids, denitrification gas, etc., remove it with a scum skimmer and send it directly to the sludge treatment process so that it does not adversely affect the biological reaction tank.

The removal of scum is achieved by lowering the depth of the scum recovery opening part (drainage section) below the surface level of the sewage surface, allowing the scum and sewage to efficiently flow into the drainage trough / drainage pipe due to the difference in water level, and collecting the scum in the scum pit under gravity flow.

In addition, since the scum pit is installed near the water surface, it is affected by the mixed wave caused by the agitation of the sewage and Power of buoyancy.
The following points shall be noted when constructing the scum skimmers.

- The scum skimmer has sufficient strength and is fixed to the wall.
- The material selected shall be highly corrosive.
- The scum recovery opening part shall be installed at the same level as the water surface.
- The scum generated on the back of the scum skimmer can be removed.
- When the scum skimmer is not operated, the scum recovery opening part shall not be affected by the mixed wave and high-water level.
- When the scum skimmer is under operation, the water level of scum recover opening part should be lowered to a maximum depth of 100mm.
- The operation of the scum skimmer should be performed manually while checking the scum occurrence.
- The removed scum and sewage will be drained smoothly.
- The bearing part / bushing shall have a structure that allows easy operation of the scum skimmer, easy installation accuracy work, corrosion resistance, and does not cause operation failure due to adhesion of the scum.

8.20 Primary/Secondary Clarifiers

Circular (radial), fixed bridge with scum collector, Central turns drive type, collecting effectively with proper circumferential speed, clarifiers shall be provided. The clarifier shall be rugged and robust in design and shall be provided with high capacity drive head and induction motor having high torque rating, centrally located, with positive sludge raking by means of one or more raking arms. Both the raking arms should have scraper blades fitted at the bottom, so that the sludge from scraper blades is pushed to the sump on every rotation.

(a) The drive head mechanism arrangements shall consist of a turn table base casing mounted on top of the centre pier and shall have an angular ball bearing mounted internal gear that supports the underwater mechanism. The pinion meshing with the internal gear should be driven through a worm gear reduction unit mounted on top of the turn table drive unit. The balls should ride on hardened steel strips set into grooves in the base and gear casing so that they can be readily replaced whenever required.

(b) The unit will have mechanical overload arrangement with a torque indicating arrangement along with necessary contacts for tripping the motor in the event of overloading. This condition shall be annunciated. The unit shall have push button station near the motor and starter with push button shall be provided in the control room, i.e. the return activated sludge pump house along with necessary switches. The clarifier unit should also be provided with necessary M.S. scum trough, scum baffles, skimmer assembly, M.S. rake blades, arms and brass squeezes. The V-notch weirs shall be 6 mm thick of SS 304 with SS 316 clamps & fasteners etc. for making the necessary adjustments.

(c) Scrapers supplied by the Contractor shall generally be manufactured in protected mild steel, in accordance with the requirements of the Specification and especially where Mild steel is proposed for underwater structure, the part shall be coated with polyurethane for a minimum 180 to 250 microns.

(d) Material such as stainless steel (SS316) shall be provided for specific items as sludge scraper blades. Where mild steel is proposed, the protection system shall give a typical life to first maintenance of at least 15 years.

(e) The bridge connecting the periphery of the tank to centre pier shall have walkway covered with chequered plates and provided with hand railing on both sides.

(f) The Clarifiers shall have a bridge complete with 1200 mm walkway for personnel access to the centre, access stairs to ground level and hand railing, a motor driven sludge scraper complete with all necessary controls, delivery pipe work, a stilling well and overflow steel weir plates. Hand railing, MS Chequered plate walkways of minimum 6 mm thick, access steps etc. shall be galvanized. Handrails shall be of tubular construction and made of 50 NB pipes heavy duty class.

(g) The scrapers shall be fitted with rotation monitors and over torque protection to alarm in the event of a failure.

1) Corrosion allowance of 2 mm shall be taken in the structural sections of scraper arm, bridge etc.
2) Structural design calculations shall be submitted for all structures including scraper arm, bridge etc. and also the calculation for drive head selection including the Torque Rating.

(h) Scum collected by the scum skimmer is effectively collected in a scum box, and it is mix with excuses sludge pump and dehydrated.

(i) Clarifier sludge draw-off pipe shall be provided with a Manual & Motorized Knife Gate valve and flowmeter measurement.

8.20.1 Rectangular Sedimentation Tank

General

Rectangular Clarifier or Sedimentation tanks shall have a length to width of not less than 4:1. It can be installed in Single/Two/Three Deck system. The sludge collector shall be a chain flight type and be installed for the purpose of scraping the settled sludge into the hopper provided by the side of the tank.

Each tank shall have wastewater delivery in the form of an inlet channel spanning the entire width of the tank and multiple submerged ports for low turbulence inlet feed into the tank.

The sludge collector shall be constructed with endless chains having flights mounted at definite intervals. The endless chain shall be driven through sprockets on the drive shaft and idle shaft to move the flights along the rail surfaces on the tank bottom so that the sludge may be scraped into the sludge hopper.

In this construction, the scum generated on the water surface in the clarifier is scraped from the return side of the sludge collector so that it may flow into the scum skimmer.

The scum removal equipment at the effluent end of the tank shall consist of a rotatable pipe trough with a longitudinal slot running of the pipe. The pipe shall span the width of the pass/tank and discharge into a scum accumulation chamber. The scum trough shall be rotated via the use of a handwheel actuated gearing with extended spindle.

For extremely long sedimentation passes/tank, the maximum length of the chain and flight system for each pass shall not exceed 60 m.

Design Conditions

(1) Collector chain

(a) Type: Engineering Plastic or SS 316 L

(b) Pitch: About 150 to 200 mm

(c) Rupture strength: Guaranteed minimum: 15 kN

: Average: 20 kN

(2) Sprockets

(a) Pitch: About 150 to 200 mm

(3) Scraping speed

(a) Primary clarifier: About 0.6 to 0.8 m/min

(b) Secondary clarifier: About 0.3 to 0.7 m/min

(4) Collector flight mounting pitch: About 3 m

Fabrication

(1) Drive unit

The drive unit shall be a horizontal cycloidal reduction gear or planetary reduction gear. Power shall be transmitted by chain transmission system and the speed shall be reduced to the predetermined sludge scraping speed. The transmission chain shall be arranged on the sprockets with the return side up, as a rule.

The drive chain which will be submerged in water shall be a stainless steel SS 316L.bushed chain. Or, a chain tightener shall be provided, as necessary.

(2) Collector chain

The chain shall be made of Engineering Plastic or SS 316L chain with high wear resistance and corrosion resistance. It shall be constructed easy to disassemble and adjustable in chain elongation.

(3) Sprockets

(a) For the sprockets for the drive chain, a special pin type wheel (if any), shall be used considering wear.

(b) For the sprockets for the collector chain, a special pin type wheel (if any), shall be used for the drive shaft considering abrasion, and a Engineering Plastic or SS 316L sheave type wheel for the idle shaft.

(4) Collector flights

(a) Collector flight material shall be of fiber reinforced plastic, FRP.

(b) For each tank, rubber plates to scrape the sludge to the tank bottom surface shall be mounted at ends of two collector flights.

(c) Regarding wear shoes, adequate consideration shall be given to their mounting intervals, etc. and an adequate allowance for wear shall be provided, so that the collector flights may not contact the concrete wall, bearing stand, rail holder, etc. and the collector flight strength may not be damaged.

Accessories shall be supplied along with steel plate common base, Drive unit and chain cover,

Mounting bolt and nut Anchor bolt and nut.

Chain and flight mechanism shall have material of construction as below:

(1) Collector chain

(a) Chain main body: Engineering Plastic or SS 316L

(b) Pin: Engineering Plastic or SS 316L

(2) Shaft

(a) Drive shaft: Stainless steel SS 316L

(b) Idle shaft: Engineering Plastic or SS 316L

(3) Bearing

(a) Drive shaft bearing: Engineering Plastic or SS 316L

(4) Sprockets

(a) For collector chain for idle shaft: Engineering Plastic or SS 316L

(5) Collector flights: Fiber reinforced plastic (FRP)

(6) Guide rails: Stainless steel SS 316L

(7) Bottom rails: Engineering Plastic or stainless steel SS 316L

(8) Guide rail bracket: Stainless steel SS 316L

(9) Wear shoes: Engineering Plastic or stainless steel SS 316L

(10) Anchor bolt and nut: Stainless steel SS 316L.

Protection Equipment

(1) Electrical protection equipment: Electrical components shall conform to relevant local or IEC standards.

- Overcurrent detector/relays for overload protection (electrical works)
- Short circuit protection

(2) Mechanical protection equipment

Speed reducer built-in torque limiter for overload protection

8.21 Gravity Thickeners

Circular (radial), fixed bridge, central turn table type or peripheral drive type picket fence, collecting effectively with proper circumferential speed, a clarifier shall be provided. The Thickener shall be rugged and robust in design and shall be provided with high capacity drive head and induction motor having high torque rating, centrally or peripherally located, with positive sludge raking by means of one or more raking arms. Both the raking arms should have scraper blades fitted at the bottom, so that the sludge from scraper blades is pushed to the sump on every rotation. It is fundamental to treat sludge with a sufficient cohesive effect.

When the excess sludge with insufficient coagulation effect is concentrated by gravity, if the concentration time is long, phosphorous is released from the aerobic sludge, and the phosphorous concentration of the supernatant water may increase. Therefore, the mixed sludge treatment of the scum generated from the excess sludge, the biological reaction tank, and the final sedimentation basin needs to be processed promptly. Scum generated in the thickener is removed by a scum skimmer and processed appropriately.

(a) The circular reinforced concrete thickeners tapering at bottom shall be provided for thickening process.

(b) Design shall be such that the sludge can become compacted and can be extracted from the bottom. Interstitial liquid flows through peripheral weir at top. Tanks shall be deep enough to allow the sludge to settle. At least 50 cm freeboard shall be provided. Provision shall be made to remove the sludge from top if there is a serious risk.

(c) Provision shall be made for collection of thickened sludge and pumping it to Centrifuge.
A full diameter bridge with walkway with central drive shall be provided with: central platform for the installation of the scrapers and their drives and for the local control panel; a radial scraper system with bottom scraper blades, suspended on the bridge.

(d) The thickeners shall have a full diameter fixed bridge complete with 1200 mm walkway for personnel access to the center, access stairs to ground level and hand railing, a motor driven sludge scraper complete with all necessary controls, delivery pipe work, a stilling well and overflow steel weir plates. Hand railing, MS Chequered plate walkways of minimum 6 mm thick, access steps etc. shall be galvanized. Handrails shall be of tubular construction and made of 50 NB pipes heavy duty class.

(e) The scraping gear shall be supported from the tank base and from a fixed bridge carrying the central electrical drive for the rotating gear. The equipment including driving motor, gears, shafting and scrapers shall be designed for continuous operation and sized for the most arduous operating condition including starting from rest with an accumulation of sludge in the thickeners.

(f) The electric motor, gearbox etc., shall be provided with a sunshade (Canopy).

(g) The fixed bridge, hand railing, access steps and the feed well shall be galvanized steel. The main drive shall be cast Iron construction and shall be enclosed in a dust proof enclosure with oil bath lubrication. All underwater hardware shall be of SS316.

(h) Suitable overload protection for the drive shall be provided to ensure that the sludge shall not overload the equipment and emergency stop pushbutton shall be provided.

(i) The scrapers shall be fitted with rotation monitors and over torque protection to alarm in the event of a failure.

1) Corrosion allowance of 2 mm shall be taken in the structural sections of scraper arm, bridge etc.
2) Structural design calculations shall be submitted for all structures including scraper arm, bridge etc. and also the calculation for drive head selection including the Torque Rating.

(j) V-notch weir in SS 304 construction of size minimum 6 mm thick and 200 mm wide shall be provided along the launders for uniform draw-off of the overflow. The weir plate shall be fixed to the launder by means SS 316 grade clamping plates and fasteners.

The hydraulic equipment will consist of the DI inlet pipe (runs along the bridge) to the central feed well of the thickener; sludge draw-off pipe with an manual & Motorized Knife Gate valve (in SS CF8M material of construction) for intermittent operation according to an adjustable timer; a drain pipe with manually operated gate valve for the complete emptying of the unit; a discharge pipe/channel from the peripheral collecting channel to the main channel leading to the Supernatant sump.

(k) The sludge thickener mechanism shall be generally in MS galvanized construction, suitable for installation in a circular RCC tank and shall include the following:

a. Mechanism support beam spanning the diameter of the tank.
b. Walkway and handrail from the edge to the centre of the tank.
c. Drive mechanism with internal gear type.
d. Reduction gear box.
e. Chain and sprocket with guard.
f. Central shaft with scrapper arm and picket fence.
g. Skimmer Scum Baffle and Scum trough.
h. Overflow weir:
i. Vertical pickets.
j. Torque Indicating Device.
k. Overload Alarm protection.
l. Auto lifting device with minimum 300 mm lift.

8.22 Dewatering Centrifuges

(a) The Dewatering Machine and its peripheral equipment shall include but not necessarily be limited to the following;
(1) Powder or liquid Coagulant storage tanks.
(2) Mixers and solution tanks.
(3) Coagulant service tanks.
(4) Supply line & flush line.
(5) Chemical feeding pumps.
(6) Water supply pumps.
(7) Sludge feeding pumps.

(8) Dewatering Centrifuge
(9) Screw conveyor.
(10) Cake hopper.
(11) Flow meters for feeding Sludge, and for feeding chemical solution.
(12) Control valves on sludge feeding line, and on Chemical feeding line.
(13) Drain system.

(b) Dewatered cake shall be conveyed by a screw conveyor to cake hopper for carrying out for reuse. The performance of the centrifuge shall be taken into account the conditions necessary for dumping the dewatered cake to the waste disposal site by a truck.

(c) To select the type of dewatering machine, Contractor shall provide technical information to show client that performance to obtain his approval in advance.

(i) Decanter Centrifuge

The centrifuge shall comprise a conical cylindrical bowl and scroll feed horizontally mounted in bearings on a frame. The centrifuge bowl and scroll support frame shall be mounted on a fabricated steel sub-frame.

The bowl and scroll shall be made from stainless steel AISI 316 material. The leading faces of the scroll shall be protected against abrasive wear by the application of a suitable hard-coated material (Tungsten carbide).

The whole rotating assembly shall be enclosed by a Stainless steel (AISI 316) fabricated casing incorporating a Centrate discharge hopper and outlet pipe, and a rectangular solids hopper which shall discharge the dewatered sludge into the disposal system.

The rotor shall consist of a solid bowl which is conical-cylindrical in shape and which rotates about a central shaft. An inner scroll shall be provided to convey separated sludge from the periphery of the cylindrical bowl to the beach at the conical end of the rotor.

The main scroll bearings shall be arranged for lubrication by an external lubrication system. Wherever practicable greasing nipples shall be arranged together as a battery. The complete rotating assembly shall be dynamically balanced and test certificates provided.

Sludge shall be fed into one end of the rotor through a centrally positioned feed tube and dispersed to the bowl through an inlet chamber.

The bowl shall be provided with an adjustable 360^{o} peripheral weir at its cylindrical end to control the depth of the Centrate in the rotor.

The fixed outlet castings of the rotor shall be designed to collect the centrate and dewatered sludge from the rotor. Baffles within the casing shall direct the separate phases to the relevant discharge points and prevent cross-contamination.

The centrifuge shall be mounted on heavy-duty vibration isolators, located between the machine and the supporting steelwork or foundations, to damp vibrations and prevent vibration transmission. Two axis

vibration monitors shall be provided to stop the centrifuge automatically when excessive vibration is detected.

Flexible connections shall be provided on the sludge fed system and the Centrate system in the centrifuge. The dewatered sludge discharge system shall incorporate flexible chutes.

(ii) Variable Speed Drive

A variable speed drive shall be provided to accelerate the rotor to operational speed and maintain that speed during the centrifuge's duty period. The bowl drive shall be electric or hydraulic and shall be coupled to the drive shaft by a multiple 'V' notch belt drive.

(iii) Differential Scroll Drive

The scroll drive shall be provided with a separate drive mechanism to control its rotation in the same direction but at a different speed to the outer bowl. The differential speed shall be adjustable. The Centrifuge shall have both front drive and Back drive mechanism.

The drive shall be linked to the main bowl drive by an epicyclic gearbox. The differential speed of the scroll shall be automatically and manually adjustable so that the moisture content of the dewatered sludge can be controlled as required.

For safe operation, contractor shall provide control panel showing proper Sequence of operation with interlocking.

Chutes and interconnecting piping shall be provided with flexible joint (minimum 10 mm flexible in all direction) to avoid vibration.

8.23 Conveyor System

(a) For the disposal of sludge a common motor driven endless belt conveyor shall be provided. The conveyor shall be designed in accordance with IS 11592 or equivalent. The conveyor and chutes shall be suitable for handling occasional heavy objects which will cause shock loads.

(b) The construction of the frame and support shall be robust and torque resistant. Belt conveyor shall be of 20 deg. Trough type complete with drive assembly structures, idlers, pulleys and belt cleaners. Idlers and pulley shall be provided with anti-friction bearings.

(c) The belt material shall be two ply nylon or equivalent with minimum 3 mm neoprene covering on carrying side. Splicing shall be employed to make the belt endless. The belt shall operate over three roll twenty degree, troughing idlers. The idlers shall rotate on precision type, deep groove, single row ball bearing with built-in close fitting triple labyrinth grease seal. The ends of the outer shell shall be counter bored and a full length centre tube journalled concentricity. The outer shell, centre tube and precision die formed steel ends shall be brazed into an integral unit to provide concentricity. The ends of the centre tube shall be bored concentrically with each other after roll assembly to provide correct bearing alignment and to provide prestressing of boring. The centre tube shall be grease fit after assembly. Troughing idlers shall have means of adjustment or ensuring belt tracking. On the return run the belt shall operate over

flat roll idlers having bearing, shaft and lubrication arrangements as above for carrying idlers. Spacing of idlers shall be of 1200 mm on carrying run and 2400 mm on return run.

(d) The head and tail pulleys shall be manufactured from welded steel/any alloy steel and shall be provided with rubber lagging. Lagging for drive pulleys shall have herringbone grooving. Pulleys shall be equipped with taper lock bushings. The tail pulley shall incorporate a screw rake for adjusting belt tension. Head and tail pulleys shall be adequately guarded.

(e) Shafting for pulleys shall be of heat-treated carbon steel. They shall be forged, ground and polished to obtain close diameter tolerances. The head shaft shall be provided with roller bearing pillow blocks.

(f) The belt conveyor shall be driven by a squirrel cage, TEFC motor. A V-belt drive arrangement shall be provided between the motor and a helical speed reducer, the latter shall be mounted on the end of the head shaft. The driving pulley shaft shall have back stops to prevent backward movement of the belt.

(g) The conveyor shall be supported on appropriate channel sections with 14-gauge steel deck plate between the two runs of the belt and the necessary supports to the floor. The floor supports shall be made out of steel plates having minimum 6 mm thickness. The conveyor shall be protected from weather by a 'dog box' type canopy.

(h) An adjustable belt scraper shall be provided on the hopper end of the conveyor belt. The scraper and attachments shall be of fiber-reinforced plastic.

(i) Sludge cake discharge Hoppers shall be provided to transfer the sludge cake from the Centrifuge to the troughed belt conveyor and from the conveyor discharge to skip. The latter chute shall extend beneath the belt scraper and shall allow access for maintenance of the belt scraper. Chutes shall be designed to minimize the accumulation of rags and stringy materials. The sludge cake hopper shall be of MS fabricated with minimum 10 mm thick corrosion resistant painting applied, and it shall be operated by a motorized cut gate for auto operation with load cell arrangement in the plant. The cake hopper minimum dewatered sludge holding capacity shall be at least for 2 hours.

(j) The conveyor shall be fitted with an emergency stop operated by wire rope at foot level. Two Nos. belt sway switches shall be provided on conveyor.

8.24 Progressive Cavity Pumps

(a) Pumps shall be of the type in which a pumping action is generated by a helical rotating eccentrically within a resilient stator in the form of a double internal helix. The eccentric motion of the rotor shall maintain a constant seal across the stator as it travels through the pump to give a uniform positive displacement.

(b) Pumps shall be arranged generally with a single shaft seal at the suction end. Mechanical seals shall be used. If a flexible shaft is used to accommodate the eccentric motion, a corrosion-resistant shroud shall be fitted to prevent fiber build-up on the shaft. Enlarged inspection access holes shall be fitted to the suction chambers of all pumps for periodic removal of

accumulated debris. The shaft bearing shall be positively isolated from the fluid being pumped.

(c) The rotor material shall be selected for corrosion and abrasion resistance for the fluid being pumped, and for prolonged service life. Hard chrome or other approved coatings shall not be less than 250 micron thickness and shall be diffused into the base material. The rotor shall generally be single-stage and shall incorporate not less than 360^0 of twist, but for high-head applications, it may be necessary to use more than a single-stage. The stator shall be of a resilient material selected for chemical and abrasion resistance for the fluid being pumped. Pump speed shall suit the application, where variable delivery output is needed; the pump shall be provided with a variable-speed drive. The size and speed range of the pump shall ensure that the highest expected duty point shall lie within the available speed range.

(d) Pumps shall normally be driven by a fixed-speed electric motor through reduction gearing and the combined drive shall be continuously rated. Pump and motor shall preferably be mounted in-line on a common base plate.

(e) Coupling guards shall be provided, which shall be rigid, securely fixed, and designed so that removal is not necessary during normal operation, routine maintenance and routine inspections.

(f) All motor enclosures shall be provided with ingress protection to IP55. Motor anti-condensation heaters shall be provided and shall be suitable for use on a 220V single-phase, 50Hz supply. All bearing shall have a L10 design life of not less than 100,000 running hours and shall be designed for loading 20% in excess of calculated maximum loading.

(g) Pumps shall be fitted with individual dry-running protection to initiate pump trip. Dry-running protection by 'under-current' monitoring or 'pipeline-intrusive' device shall not be used.

Material of Construction;

S. No.	Component	Material
1	Pump Housing	CI IS210 Grade 260
2	Rotor & Coupling & Connecting Rod	SS AISI 316(HCP) 250 Microns
3	Shaft	SS AISI 410(HCP) 250 Microns
4	Stator	Nitrite black
5	Type of drive	V belt & Pulleys
6	Base plate	MS fabricated
7	Mechanical seals	oil-lubricated with tungsten carbide or silicon-carbide faces

Pumps models (handling water) shall be selected such that when handling sludge it meets the required duties of the viscous liquid. Pumps shall be selected which gives the required duties close to best efficiency point.

8.25 Chlorination System

Chlorine solution diffusers shall be supplied and installed at the dosing point.
Treated sewage shall be dosed with chlorine gas at concentrations not more than 10 mg/l. Effluent from the chlorine contact tank shall not have more than 1 mg/l of residual chlorine.

8.25.1 Chlorinators

(a) Vacuum-type chlorinators shall be supplied with one duty and one standby unit.

(b) Chlorinators shall be free-standing, floor-mounted, and shall have a turn down ratio of 10: 1 over the full range of works operation.

(c) Each chlorinator shall be equipped with a motorized plug positioned to be actuated by a sewage flow at the works outlet.

(d) The dosing rate shall be manually set and each chlorinator shall be equipped with a 0 to 10 mg/l scale and a manual dose setter over the complete range.

(e) Mal-operation of the duty chlorination system shall be indicated in the chlorination room and the central MMI. The change to the standby system shall be carried out automatically in the event of a duty chlorinator failure.

(f) Chlorine solution Diffusers shall be supplied and installed at the dosing point.

(g) The plastic sheathed copper tubes connecting the liquid chlorine drums and the liquid chlorine header system shall be equipped with adaptors to accept drums supplied by the Employer.

(h) Flanges and Joints for Liquid Chlorine Pipe Work

Flanges for liquid chlorine pipe work and valves shall be raised face flanged double fillet welded, stress relieved and radiographed, drilled to relevant tables of BS EN 1092-1.

Joint rings shall be 2 mm compressed Asbestos Fibre (CAF) tabbed to BS: 2815 Grade B fitting within the bolt circle. Prior to installation the joint rings shall be impregnated / smeared with graphite compound or similar jointing compound compatible with liquid chlorine.

(i) Liquid Chlorine Pipe Work

Pipe work conveying liquid chlorine shall be carbon steel hot finished seamless, cold drawn seamless to BS: 3602 Class 23 or 27. Pipe work shall be adequately supported throughout its length and sufficient number of flanges shall be incorporated to enable maintenance or repairs to be carried out without having to work from one end of the pipe work.

The pipe work shall include rupture disc and expansion chamber as per recommendations of Chlorine Institute, USA. An alarm switch shall be provided set to function if rupture occurs.

Following any welding work on the pipe work the entire section of the affected pipe work shall be stress relieved and radiographed.

(j) Valves for Liquid Chlorine

Valves for liquid chlorine duty shall be Polytetrafluorethylene sleeved plug type 2-way valves with carbon steel body and Monel plug.

Where the valves are manually operated, they shall be wrench situated with padlock type locking feature.

Power actuated valves shall have electric actuators with built-in position feedback limit switches, torque overload protector, IP 56 enclosures and manual override facilities.

(k) Chlorine Pressure Gauges

Pressure gauges for use with chlorine shall be of the Bourdon tube type with a special diaphragm isolating the tube from the liquid or gaseous chlorine. Pressure gauges shall have dials not less than 150 mm diameter except where they form an integral part of equipment, such as a chlorinator. No aluminium shall be used in the construction of the gauges; the dials and bezels shall be of bronze and internal components shall be of a stainless steel or other alloy or Corrosion resistant material against chlorine usage.

All pressure gauge piping shall include isolating valves at each point of connection to the main piping.

Where necessary, pressure gauges shall be fitted with adjustable electrical contacts for initiation of alarm conditions with either rising or falling pressure, to suit the system design.

(l) Automatic Drum Changeover Panel

The automatic drum changeover panel shall be a specially designed unit capable of selecting liquid chlorine containers for duty on an alternate basis. The unit shall be capable of working in conjunction with four liquid chlorine drums (two duty, two standby).

The panel shall satisfy the following duty functions in chronological order:

Check pressure in the line initiate automatic changeover and alarm if pressure is low;

Shut the delivery valve of the drum that has just become empty and open the valve of the standby drum on-line;

Re-check pressure as in (1) above and initiate alarm if pressure is still low;

Proceed until next changeover is initiated, then repeat the sequence;

At each step, the operation of valves shall be monitored using position feedback limit switches and valves failing to operate in a set time shall immediately initiate an alarm.

(m) Chlorine Gas Pipe Work

Pipe work conveying chlorine gas shall be solid draw steel tube to B.S.1387 with BSP taper threads to B.S. 21. All fittings shall be of malleable iron. Chlorine gas pipe work shall be adequately

supported. Threaded joints shall be sealed using jointing compound compatible with chlorine. Poly tetrafluoroethylene tapes shall not be acceptable.

Where installation involves injectors to be located near the dosing points or remote injectors, the vacuum chlorine gas delivery lines downstream of chlorinators shall be of uPVC or approved equivalent and the lines to be run in RCC ducts with proper Pre-cast covers.

(n) Chlorine Gas Valves

Valves for gaseous chlorine duty shall be specifically designed for chlorine with forged steel bodies, Monel valve packing or special diaphragm in chlorine resistant materials.

(o) Chlorine Gas PRV and Shut-Off Valves

Chlorine Gas Pressure Reducing and shut-off valve shall be a spring loaded, diaphragm operated valve with super-imposed electric actuator designed to reduce varying gas pressure upstream to a desired regulated pressure downstream and maintain this pressure within close limits.
The diaphragm shall be made of Polytetrafluorethylene (PTFE).
The electric actuator shall ensure quick shut-off of the gas flow in the event of a breakdown or similar event.

(p) Injector Motive Water Supply System

Injector water supply system shall be compatible with the flow and pressure requirements at the maximum rated output of the chlorinators offered and to limit the chlorine solution concentration to an acceptable limit at operational fluid temperature up to 330 C.

(q) Chlorinators

The chlorinators shall be vacuum operated aqueous solution feed type units working in conjunction with wall-mounted injectors.
The units shall be discrete floor standing cabinets of plastic/composite construction. The chlorinators shall be suitable for manual feed rate control and incorporate a flow metering device for precise regulating of chlorine gas over a 20:1 flow range, with a metering accuracy of plus or minus 4% of the indicated gas flow rate.
Each chlorinator shall be fitted with the following principal components;

a) Gas inlet pressure regulating valve.
b) Pressure/vacuum relief valve with safety vent.
c) Vacuum regulating valve.
d) Gas feed rate regulator preferably of the 'V' notch cylindrical plug and variable area orifice type.

e) Variable area type flow meter with linear feed rate indicator calibrated in kg/hr

f) Thermostatically controlled gas inlet heater

g) Wall mounted injector, preferably of adjustable throat type

h) Rigid PVC pipework to wall mounted remote injectors.

i) Chlorinators shall be provided with panel mounted indicators for the chlorine gas inlet pressure, injector vacuum, motive water pressure, chlorine solution pressure immediately downstream of injector and a feed rate adjustment knob.

j) Chlorine gas feed piping shall be provided with valves to allow isolation of each chlorinator without disturbing the operation of the other chlorinators.

k) Rigid PVC chlorine vent piping shall also be provided and arranged to discharge at a high level outside the room housing the chlorinators to ensure safe atmospheric dilution.

l) The chlorine supply to the injector shall shut down automatically if:

- The water supply to the injectors shall fail
- The injector vacuum line should break
- The chlorine solution line should be accidentally shut down by the closing of a chlorine solution dosing valve.

m) A check valve shall be provided between chlorinator and injector to prevent accidental backflow into the chlorinator. This shall be consistent with the injector design with respect to gas flow and water pressure. While effectively preventing backflow, this valve shall allow requisite gas flow.

n) Additional safety devices shall be incorporated in the equipment to prevent hazards to the operators or damage to the components under normal operating and shutdown conditions.

o) All electrical services and control signal lines (where applicable) shall be wired to a single termination board within the chlorinator cabinet. The termination board shall preferably be totally enclosed in a gas-tight junction box with glanded cable entries and fitted with a clearly labelled warning sign stating the supply voltage. Electrical supply isolating switches interlocked with the panel doors shall also be provided in each chlorinator cabinet.

(r) Chlorine Draw-Off System

Chlorine shall be drawn off as gas; to minimize drum handling there shall be adequate connections and drum isolating valves provided to enable one drum from each row to be connected to the automatic drum changeover device to be provided under this Contract.

The local supply of liquid chlorine may contain 0.1% to 0.2% ferric chloride and about 50 mg/l moisture. Tenderers shall provide for suitable devices such as filters so that the pipe work and equipment are protected against deposits or corrosion.

The duty/standby drums shall be located on plinth-mounted casters with four rollers per set or drums. The casters with rollers for these drums shall be supplied and installed under this Contract.
The installation shall include all necessary chlorine headers including supports, power actuated valves and manual isolating valves, for connection of drums to the drum changeover device.
The liquid chlorine pipe work interconnecting the drums, changeover panel and the liquid chlorine evaporator shall be safeguarded by a pressure relief system.
The pressure relief system shall comprise locked open isolating valves, bursting disc assembly, pressure gauge with adjustable alarm contacts and relief vessel.
The bursting disc shall preferably be made of nickel sheathed in PTFE, or approved equivalent.

(s) Chlorine Solution Delivery Pipe Work and Valves

The Contractor shall provide all necessary rigid pipe work, valves and fittings for the delivery of the chlorine solution from chlorinator injectors/manifold to the points of application.

The chlorine solution delivery lines shall be of Mild steel ebonite lined or approved equivalent. The pipe work shall be adequately protected externally against corrosion and installed complete with necessary supports, thrust restraints, etc., and incorporate sufficient flexibility to allow for any thermal expansion effects.

When selecting material for pipe work, consideration shall be given to the deteriorating effect on some synthetic materials due to the action of ultra-violet rays. Where such materials are employed, particularly in the case of uPVC, pipe work shall be shielded from direct sunlight.

The valves in the chlorine solution pipe work shall be of cast iron body, flanged, rubber lined valves of the diaphragm type or approved equivalent. Locking devices and position indicators shall be provided. The diaphragm of the valves shall be PTFE faced with a backing of viton synthetic rubber (co-polymer of vinylidene fluoride and hexa fluoropropylene).

Test pressure for the solution delivery pipe work, valves and specials shall be twice the working pressure or 1 1/2 times the shut-off head of the injector motive water pumps, whichever is higher.

(t) Chlorine Solution Distributors & Injection Fittings

Where chlorine solution is to be dosed into flow in an open channel, chamber or downstream of a hydraulic jump it shall be applied using a chlorine solution distributor.

The distributor shall be either tube drilled ceramic tubular diffuser, designed to ensure uniform distribution of the specified flow rate of chlorine solution at the point of application.

The materials of construction of the distribution and sealing shall be compatible with 3500 mg/l chlorine solution at operational fluid temperature up to 30°C. Porous ceramic material where used shall be inert, and non-toxic, uPVC tube where used shall conform to BS:3505 Class 'E'.

The distributor shall be adequately supported and designed to withstand the stream velocity at the point of application and any flow or turbulence induced vibrations.

Where chlorine solution is to be dosed into flow in pipe lines it shall be applied using an injection fitting/device designed for specified duty flow rate.

The injection tube shall extend across the pipe bore and be supported with ends located in diametrically opposite flanged branches.

The injection fitting shall be installed in diametrically opposite flanged branches with their axis making an angle of 45° with the horizontal in a plane normal to the direction of flow within the pipe line.

The injection fittings shall be adequately supported and designed to withstand the flow or turbulence induced vibrations. Provisions shall include necessary support brackets also.

Chlorine solution distributors or injection fittings shall be supplied complete with necessary non-return and isolation valves.

(u) Tonner Roller Supports

These supports shall be used to hold the Tonner containers securely in place and also to facilitate the positioning of the Tonners, so that inbuilt valves (Gas side and Liquid side)
The Roller support body shall be made of Cast Iron, rollers shall be Cast Iron/Mild steel, Bushes shall be of Brass and Rollers shall be carbon steel with cadmium plated.

(v) Lifting Beam with Hooks

To facilitate safe lifting of standard Tonner container, the lifting Beam with hooks shall be provided.
The Beam shall hold the Tonner securely while hoist and Trolley are used to lift, place and position the containers. The Beam material shall be Cast Iron/Mild steel.

(w) Chlorine Plant Ventilation

The Container Store area and the Chlorinator Room shall be made reasonably gas tight and provided with separate forced ventilation facilities. A ducted system shall be provided with a number of fan units such that even though any one unit fails reasonable ventilation would still be effected.
Inlets to the exhaust duct system shall be placed at the floor level. The exhaust system shall directly discharge air to atmosphere outside the building.

Each exhaust system shall include two sets of fans, one for continuous running giving 4 air changes per hour and the other designed for intermittent running giving 20 air changes per hour.

Movable louvers shall be provided on the inlet and outlet ports of the forced air circulation system. The louvers shall open automatically when the ventilation is started and closed by gravity when stopped. Contactor starters for operating ventilation equipment shall be provided in the motor control center in the Office and Control Room as well as local to the units, and be subject to shut-down control from leak detection units. Ductwork (Minimum 400mm ID) shall be manufactured from Aluminum sheets/PP (3mm) +FRP (5mm) in circular or rectangular sections.

All necessary ducting, self-closing louvered outlets, exhaust fans with external mounted control gear indicator lights shall be provided under the Contract. Special attention shall be given to materials of construction and particularly to motor protection.

(x) Chlorine Container Weighing Equipment:

Equipment provided for weighing chlorine containers shall be spring type loaded with circular scale indicator and shall conform to IS: 1438.
The weigher shall be designed suitable for suspension from the load hook of Lifting Beam to be properly secured to the crane or hoist.

The weigher shall be suitable for operation with a working load of not more than 2000 kg. The indicator scale shall be calibrated in 5kg divisions, with the zero at the top of the scale and the pointer vertical with no load. The pointer shall incorporate means of tare adjustments up to 20% of the indicator scale. The indicator dial shall be slanted from the vertical plane so as to minimize parallax errors when the indicator is read from the floor with the unit hoisted to a high level.

The weigher shall have an overall accuracy of better than 10% of the full-scale deflection and the unit shall be unaffected by the temperature variations in the range 4 to 50°C.
Bidders are encouraged to propose Digital type weighing Equipment and shall be subject to approval by the Engineer.

(y) Safety Equipment:

Materials and equipment necessary to ensure the safety of personnel operating the chlorination plant and others shall be provided.
The equipment shall include inter alia:

i. Two sets of approved self-contained breathing apparatus, each comprising an air set, carrying harness, face mask and valves and ancillary equipment. Each set shall be provided with three 1 200 litre capacity, 140 mm diameter, air cylinders;
ii. Two sets of approved positive airline breathing apparatus, each comprising body harness, face masks and valves and 30 m of airline. One air trolley, comprising wheeled frame with two air cylinders, control manifold, airline hose and hose winding drum. Two spare cylinders suitable for changeover shall be provided;
iii. one portable electric motor driven air compressor for recharging air cylinders, complete with quick-release air hose couplings;
iv. Two `instant action' resuscitators.;
v. Four sets of safety clothing in various sizes, each comprising PVC overalls, wellington boots with steel toe caps, goggles, gloves and safety helmets.

Each set of safety equipment shall be mounted in a glass-fronted, non-locking PVC coated steel cabinet in approved locations on the outside of the Chlorine building.

Two emergency showers shall be provided and shall be installed outside on either side of the Chlorine drum room.

Each shower shall be operated automatically by a quick acting hand or foot valve.

Four eyebaths shall be supplied. Two eyebaths shall be adjacent to each of the showers. The eye bath unit shall be fitted with fine mesh filters with built-in pressure regulating device to ensure a safe rate of flow to prevent foreign matter being further embedded into the eye and instead flush away contamination

Water for the showers, etc, shall be drawn from the service water supply.

A telephone will be provided close by outside the building for emergencies.

(z) The Tonner Room

i. Storage shall be provided for chlorine tonners sufficient for at least one month’s usage at normal rates of application.
ii. The system shall be designed to prevent freezing of the liquid chlorine at the maximum rate of withdrawal.
iii. Tonners online, tonners on standby and full and empty tonners, shall be stored separately in the tonner room.
iv. Tonner rollers shall be provided. Tonners not in use shall be stored on concrete cradles.
v. A 3-tonne overhead single girder electric travelling crane shall be provided in the chlorine tonner room for the following functions:
    (1) Offloading (and reloading) of tonner from trucks;
    (2) Handling of tonners within the storage area.

vi. The system shall serve the tonner store width over the entire length including the loading/ unloading area.

vii. The hoist and traverse speeds shall be as follows ;

(1)	Long traverse speed	:	6 m/min
(2)	Cross traverse speed	:	not more than 3 m/min
(3)	Slow lifting speed	:	1m/min
(4)	High lifting speed	:	2 m/min

viii. The container lifting beam shall be specifically designed for handling chlorine containers and equipped with necessary shackles and hooks.

ix. Operation of crane system shall be from the floor level using independent push button pendant controls operating at a 230 volt 50 Hz AC supply.

x. Two lifting beams shall be provided (a duty and a spare) and a one tonner weigher to be suspended from the crane hoist.

xi. When the pressure in the duty chlorine tonner falls to less than 1 kg/cm2 the automatic changeover device shall operate to isolate the empty tonner and to bring the full standby tonner on line.

xii. A pit and alkali absorption system shall be provided to contain and neutralise chlorine in the event of a leak. The system shall comprise a pit located in the tonner storage room, suitable pump in SS CF8M material and accessible by the overhead crane system. The pit shall be surrounded with removable guard railing. The pit shall be kept full with a neutralising solution of lime. The pit shall be capable of holding side by side two chlorine tonners. A provision shall be made to drain the pit.

xiii. In addition to the above Automatic chlorine leak absorption system (Gas Scrubber with NaOH dosing) shall be provided adjacent to the Tonner room. The process shall be designed to contain and neutralize chlorine gas vapours in response to gas leak or catastrophic cylinder failure. The system should be able to absorb 99.99% of the chlorine gas entering the scrubber.

xiv. The scrubber system shall be provided with FRP tower chlorine leak absorption system with FRP frontal hood for chlorine tonners, uPVC Ducting as per site condition, blower with two Nos. motors (1W+1S), Pressure gauge with isolation valve on blower outlet, Motorised Damper on suction side, Manual Damper on suction side, PP-FRP caustic recirculation tank, one no. level gauge on tank, one no. Dissolving basket and level switch on tank., PP diaphragm valve for drain and water inlet, One no. PP tower with packing , pump suction and strainer for pump suction, uPVC pipe on caustic pump suction of required length as per site condition, caustic recirculation pump with motor with two Nos.(1W+1S), PP diaphragm valve on caustic pump delivery, check valve on caustic pump delivery, uPVC pipe with fitting on caustic pump delivery as per site condition, pressure gauge with isolation valve on each pump delivery.

xv. When a leak occurs, the pump and fan shall start automatically. The fan shall provide sufficient vacuum to contain the chlorine gas and deliver it to the scrubber. The pump shall circulate the concentrated caustic solution over the scrubber packing to absorb all the chlorine gas.

xvi. Special consideration shall be given to any floor drainage system in the tonner building; adequate traps shall be provided to ensure that chlorine gas cannot escape. All leader tubes carrying cables or pipes out of the building shall be sealed at either end to prevent any chlorine gas leaking out.

(aa) Motive water pumps and Injector

(a) Motive water pumps (1 working + 1 standby) shall be installed.

(b) The pumps shall draw their supply from bore well/plant water supply.

(c) The pumps shall be installed outside the chlorination room and shall be made from material resistant to corrosion by chlorine.

(d) Two injectors shall be provided, each serving a duty / standby pair of chlorinators. The injectors shall be located near point of dosing i.e. upstream of Chlorine contact tank.

(bb) Chlorination Room

(a) The chlorination room shall be constructed adjacent to the tonner room but with no interconnecting door or other form of access. Chlorine injection equipment and gas cylinder shall be installed indoors.

(b) Gas lines from the tonner room into the chlorination room shall run in ducts to be sealed after installation and prior to commissioning.

(cc) Chlorine Leak Detectors

Not less than three chlorine gas leak detectors shall be provided each, with a single detector cell. At least two sensors shall be located in the chlorine tonner storage room and at least one sensor in the chlorination room. The chlorine leak detectors in the tonner room shall be mounted at each end of the tonner room.

a) The chlorine leak detectors shall have two adjustable alarm levels sensitive to chlorine concentrations above 1 mg/m3. The range of adjustment of alarm levels shall facilitate selection of the following alarms:

(1) low level 2 mg/m^3
(2) high level 4 mg/m^3

The low level alarm shall:

(1) Initiate a local audible and visual alarm;

(2) Start the ventilation fans in the tonner and chlorination rooms;
(3) Raise an alarm at the local control panel and at the central MMI.

The high level alarm shall:

(1) Initiate local audible and visual alarm;
(2) Initiate audible and visual alarms outside the buildings (the alarm shall be sufficiently loud to be heard in all buildings at the WWTP);
(3) Raise an alarm at the local control panel and at the central MMI;
(4) Shut down the chlorination systems;
(5) Stop the tonner room and chlorination room exhaust fans.

(b) The chlorine detectors shall have self-checking circuitry and detector failure alarms shall be provided at the local control panel and central MMI.

(c) Detector failure alarms shall not be combined with the leak alarms. Pilot lights and warning sound generators shall be installed in outdoors to notify gas detection.

(d) Statutory warning notices relating to the storage and handling of chlorine shall be provided. The signs shall be pictorial and provided in Kannada and English.

(dd) Chlorine Residual Monitors

(a) Chlorine residual monitors shall be provided at the plant outlet.

(b) The monitor installation shall be located in a covered location easily accessible for viewing and maintenance and shall be provided complete with sample pumps as necessary to ensure the continuity of the sample.

(c) The sampling pipe work complete with isolation valves etc. shall be designed to ensure the sample reaches the monitor in a time not greater than 1 minute. The monitor drainage pipe work shall permit the visual checking of the presence of flow and shall discharge to the foul drain. Sample sewage not passed through the monitor shall be returned to the process.

(d) The residual signals shall be displayed at the local control panel.

(e) High and low chlorine residual levels shall raise alarms at the local control panel.

(ee) Chlorination Power and Control

(a) A combined MCC and control panel shall be provided and located in a suitable location protected from the weather and the effects of the process. The control panel shall provide facilities for:

(1) Display status and values associated with the chlorination systems;
(2) Duty pump selection;
(3) Annunciate alarms associated with the chlorination systems;
(4) Operator adjustment of process set points.

(b) The chlorination systems shall operate using a fixed manually set dose rate. The quantity of chlorine dosed will therefore be adjusted in direct proportion to the process flow at the dosing point.

(c) The chlorine residual monitors to be provided shall be used for monitoring and alarm purposes only.

8.26 Disc Filter

The disc filters Partially submerged shall be gravity fed and should be capable of filtering effluent from secondary clarifiers and achieve the desired filtered water quality as follows.

Design inlet TSS, ppm : 20 ppm
Design Inlet TSS loading factor: 1.5.
Design outlet TSS, ppm : < /= 10 ppm
Total backwash water required: Shall not exceed 5% of the design influent flow.

The filters should be sized for peak flow.

The disc filters shall be furnished and installed in a free standing in concrete basin and shall include filter discs made up of individually changeable filter panels mounted on a filter drum. Each panel shall have a SS 316L with 10 microns mounted on a SS316/Poly Propylene Glass/ABS frame.

The filters shall include a gear motor/drive chain, stainless steel rotating drum with synchronous reduction gear and the chain/Timer Belt, Stainless Steel inlet channel, SS 316 Tank covers and level control mechanism. The filter shall also be supplied with a backwash system complete with pump, piping, spray pipe nozzle, control and all other accessories as required complete. All wetted metallic parts will be in SS 316 construction. Access walkways, hand railing and Staircases etc. shall be provided as defined in the tender specifications. The disc filtration unit shall be covered with Roof.

CONSTRUCTION:

a. Center Drum: The center drum shall be watertight, structurally welded and fabricated, stainless steel piece that open at one end to allow the influent to enter and shall have openings to the filter discs for distribution to the filter cloth. The drum shall have lubricated bearings externally accessible for routine lubrication.

b. Disc Assembly: Each disc will be made up of easily removal filter panels made of SS 316L with 10 microns, mounted on a SS 316/Poly Propylene Glass/ABS frame. Gaskets will be provided to seal all gaps to prevent water leakage. Each panel will filter the effluent independently without any carry over to adjacent panels in order to maintain a high filtration efficiency.

c. Filter Cover (Hood): The disc filters shall be furnished with SS316 cover with safety locking system for the purpose of service and inspection.

d. Backwash Cleaning System: Each Disc will be provided with a dedicated set of backwash spray nozzles in ceramic /engineered Plastic. Filtrate will be used as the backwashing medium. Self-cleaning nozzles should be used for continuous operation. Alternatively, a 200 micron filter should be used to filter the water going to the spray nozzles to avoid nozzle clogging. A multistage high-pressure pump with dry run protection will be provided for each filter. A level sensing mechanism will be provided to sense the hydrostatic head differential between the inlet and outlet of the filter and activate the backwash cycle.

e. Drive Mechanism: The disc filter drive shall consist of a motor with a helical worm gear and a drive chain/Timer Belt. The drive will be frequency controlled (VFD). Each filter shall have only two motors, one for the main drive and one for the backwash pump.

f. Control Panel: The filter will be configured for a fully automatic operation through a control system. The Panel shall be with a minimum IP 55 protection.

g. Spare Media: The contractor shall maintain SS316 media one unit of Disc as spare for each equipment for O&M Period.

OR

Disc Filter- fully Submerged

The disc filters shall be gravity fed and should be capable of filtering effluent from secondary clarifiers and achieve the desired filtered water quality as follows.

Design inlet TSS, ppm: 20 ppm

Design Inlet TSS loading factor: 1.5

Design outlet TSS, ppm : < /= 10 ppm

Total backwash water required: Shall not exceed 5% of the design influent flow.

The disc filters shall comprise multiple high strength and separate disc. Each disc shall be sub divided into smaller sections to constitute a prefabricated disc frame so as to ensure easy replacement and maintenance. Each disc consists of multiple panels. Each disc shall be mounted on the center drum by thread rod and strap band for the exact roundness.

The drive part of disc filter shall be of worm geared type with motor chain drive. Power shall be transmitted by SS316 chain. A protective cover made up of SS316 shall be equipped for the driver material, reduction gear and the chain/Timer Belt. Each disc will be made up of easily removal filter panels made of SS 316L with 10 microns, mounted on a SS 316/Poly Propylene/ABS frame.

Backwash system, cleaning device consists of suction cleaning unit, which conduct the suction cleaning in each side of the disc, the automatic valve and suction cleaning device shall clean the SS 316L thoroughly by the suction unit on both side of the disc with automatic valve and suction cleaning pump which shall be activated by the water level switch that contacts the water level raised with the increase of the loss of head. Disc filter shall be operated for the filtration without the stop during backwash and suction of sludge. Suction cleaning unit shall be made of or the even cleaning efficiency without dead zone for all area of filter mesh. SS316 media one unit of Disc as a spare for O&M for each equipment.

Control panel shall be SS-304 / SS-316 double/single door (inner & outer door), IP55, self-standing, floor mounted type in case of is outdoor. Control panel shall contain PLC, HMI, circuit breaker etc.,

Control panel shall accommodate an inverter/VFD to control the rotation velocity of the disc drive.

The drums shall be round type and shall have enough area in order to discharge the treated water without trouble. The material of the filter nominal pore size of 10 micron.

Central drum and Shaft shall be SS316. Mix filtration rate shall be minimum 10 m3/m2/hr.

Technical Particulars Common for both Partially Submerged or Fully Submerged type Disc Filtration System		
Design Inlet Flow (Average)	:	As per process design
Design Inlet Flow (Peak)	:	As per process design
No. of streams / disc filter units	:	As per process design
Inlet TSS	:	20 ppm
Outlet TSS	:	</= 10 ppm
Backwash Water Use	:	</= 5% of Influent
Type of Filtration Media	:	Stainless steel AISI 316
Filter Membrane	:	Stainless steel Screen / Mesh: SS-316L.
Size of Filtration / Filter membrane pore size (micron)	:	10 microns Max. or smaller as per vendor recommendation
Mounting	:	Horizontal
Filtration direction	:	In to Out / Out to In
Filter wheel diameter, mm	:	As per vendor design
Number of filter frames per wheel, Nos.	:	As per vendor design
Number of filter wheels, Nos.	:	As per vendor design
Type of Backwash Pumps	:	Horizontal or vertical mounted High-Pressure Pump for effective backwash
Cleaning Method	:	Nozzle Spray type (Partially Submerged)/ Suction type (Fully Submerged)
Required Field Instruments	:	Radar type level transmitter, Conductivity level switches (4 Point Contact) in each disc filter and Turbidity sensor for disc filter outlet
Spare Media shall be supplied for O&M	:	SS316 media one unit of Disc
MOC of Major Disc Filter Components		
Rotor / Centre drum / Distributor	:	SS-316
Protective Top cover and Body cover along with frame structure	:	SS-316 (Minimum 4 mm for Body cover)
Spray Nozzles	:	SS-316
Backwash Piping	:	SS-316
Drive Mechanism	:	Reduction Gear SS 316 reduction gear and the chain/Timer Belt and contractor's has to maintain the minimum one spare during the O&M period to avoid longer downtime of the unit.
Canopy for Main drive	:	SS 316

Control panel		
Type	:	Self-standing / Wall Mounting type, PLC based controls with HMI Screen of 10 inches. PLC shall be provided with Hardwired communication protocol interfacing with Plant SCADA system.
MOC of control panel	:	Stainless Steel SS-304 / SS-316
Protection Class	:	IP-55 & suitable for outdoor mounting.

8.27 Plant Drainage Pump set

(a) The total head capacity curve shall be continuously rising towards the shutoff with the highest at shut off.

(b) The pump shall run without undue noise and vibration.

(c) The power rating of the pump motor shall not be less than the power required from zero discharge to zero head.

(d) Pump shall be submersible type with double mechanical seals. Motor shall be of IP 68 protection.

(e) It shall be suitable for handling turbid water. Pump and motor shall have common shaft.

(f) Delivery pipe of drainage pump sets shall be of size 40 NB and as per IS 1239, heavy class. Required length of pipes and fittings shall be provided. Pumping main shall be common for two pumps.

(g) Level switch to start and stop the pump automatically shall be supplied with the pump. A level indicator shall also be provided.

(h) The capacity, total head and range of operating head of drainage pump set shall be as specified in particular mechanical requirements.

(i) The material of construction of pumps shall be as follows:

S. No.	Component	Material
(i)	Impeller	Stainless Steel :ASTM 743 CF8M
(ii)	Casing	Cast Iron : IS 210 Gr. FG 220 or 260
(iii)	Shaft	Stainless Steel: BS:970 GR 410

8.28 Facility used for domestic water

This facility shall be installed as a daily water supply facility in offices, water quality analysis rooms, etc.

Water supply pipes shall be installed in office water / shower water / toilet / water quality analysis lab water / chemical dissolving water / machinery facility cleaning water / flower bed water.

In addition, a septic tank shall be installed as a wastewater treatment for domestic water used.

1) Install a water meter.
2) Install an underground receiving concrete tank
3) Water to the elevated tank with a booster pump.
4) Install a septic tank.
5) Return the drainage to the grit chamber.

8.29 Maintenance facility using treated sewage water

The cleaning water necessary for the maintenance of the facility shall be equipped with cleaning facilities that can use sewage treated water in order to conserve tap water.

The main destination of cleaning water is vehicle cleaning / sewage treatment tank / watering.

1) Consider the following items for the construction of cleaning water facilities.

- Measures to ensure hygienic safety for workers
- Measures to prevent corrosion and blockage of facilities
- Measures to prevent misconnection with domestic water
- Measures to prevent erroneous beverages

2) A concrete washing water tank that can use storage and sewage reuse water shall be constructed.

3) Pump for cleaning water supply shall be operated at the necessary time.

4) A facility that is easy to clean shall be constructed.

5) Submersible Pumps with a water level sensor shall be installed in all drainage drain pits provided in all structures.

6) The drainage pumped up shall be discharged in wet well.

8.30 Fire Extinguishers

(a) Portable fire extinguishers are to be provided for all units as per the requirement of Tariff Advisory Committee (TAC) or meeting the requirement of local regulations whichever is more stringent.

(b) All the extinguishers shall be of TAC approved.

8.31 Propeller Exhaust Fan

(a) The fan should comply with IS 2312.

(b) The blades shall be of mild steel and properly balanced so as to avoid noise and vibration.

(c) The blade and blade carriers shall be securely fixed so that they do not loosen in operation. The means provided for securing the fan mounting or fan casing to the wall partition or window shall be such as to provide a secure fixing without damage to the fan or wall.

(d) Suitably designed guards shall be fitted to the inlet and the outlet side to prevent accidental contact. No flammable material shall be used in the construction of fan. Moulded parts, if used, shall be of such materials as to withstand the maximum temperature attained in the adjacent component parts.

(e) The fan shall have protective insulation or be capable of being earthed. A fan with protective insulation may be of all insulated construction or have either double insulation or reinforced insulation. Each fan should be provided with a 10 sq.mm mesh bird screen. The sheet used for the cowl should be 14 G.

8.32 Forced Fresh Air Circulation System

Fresh air circulation system is to be provided for the raw sewage pump house and Blower room for circulation of fresh air to limit increase in temperature and also avoid stale air presence. The complete system along with all associated required air supply fans, exhaust fans, ducts, grills, galvanized bird screens, hoods and all necessary accessories shall be provided. Suitable arrangements to prevent ingress of rain water into building shall also be provided. The system shall be designed with required air changes and the contractor shall provide detailed calculations to determine the air capacity, static pressure etc. and relevant technical details for the approval of Engineer.

All duct work shall be of high quality approved galvanized sheet steel guaranteed not to crack or peel on bending of fabrication of ducts.

The ducts shall be fabricated from galvanized plain steel sheets conforming to IS: 277-2003. All duct work, sheet metal thickness and fabrication, unless otherwise directed, shall strictly meet requirements as described in IS: 655.

All joints shall be tight and shall be made in the direction of air flow. The ducts shall be reinforced where necessary and must be secured in place so as to avoid vibrations of the duct and its supports.

Volume control dampers shall be of an approved type, lever operated and complete with locking devices which will permit the dampers to be adjusted and locked in any position.

Exhaust fans of appropriate rating shall be provided for pumping stations. The contractor shall submit the fan selection details for approval.

For axial flow fans / propeller fans, speed limitation shall be as follows:

For impeller diameter of up-to 450 mm – maximum speed shall be 1500 rpm.

For impeller diameter above 450 mm – maximum speed shall be 1000 rpm.

Suitable designed guards shall be fitted to the inlet and the outlet sides to prevent accidental contacts. No inflammable material shall be used in the construction of fans.

Drive motors shall be rated at least 15% higher than the power requirement at duty point or 10% higher than the maximum power requirements at the selected speed, whichever is higher. Motor shall be conforming to TEFC, IP 54 protection.

8.33 Air-conditioning Equipment

The air conditioning units shall be of split type, with the outdoor condensing unit mounted on the terrace of the room or grouted on external side of the wall with suitable brackets.

8.34 Air Hose Apparatus

It shall consist of full vision face mask with inhalation and exhalation valve, connected to a corrugated tube ending in a manifold non-return valve, mounted on a harness belt worn around the waist, tested to BS 1397. The 50m long, 20mm canvas reinforced wire embedded hose, connected to the manifold shall be uncrushable and shall not kink.

The radial blower connected to the hose shall be housed in a strong carrying box which can hold the breathing apparatus with hose and fittings. The blower shall be suitable for supplying air to two people simultaneously.

8.35 Surge Protection System

The Contractor shall carry out comprehensive transient or surge analysis of the complete pumping systems considering full length of pipelines under all operating conditions. The surge analysis shall be carried out using a proven and acceptable computer programme which is being used in water supply industry. The surge analysis report shall be approved by the employer. The surge analysis shall identify the most adverse transient conditions. The analysis shall include but not be limited to the following conditions:

- Tripping of all duty/working pumps (running at maximum capacity) due to complete power failure for all operating conditions.
- Start-up of the pumps under the specified control system
- Shut down of the pumps under the specified control system

The objective of the surge analysis is to recommend surge protection devices which ensures maximum and minimum allowable pressures under the operation conditions. After power failure to pumps the following design criteria shall be adopted for assessing the transient pressures:

a) The maximum transient pressure shall be less than the pipeline design pressure which in about 1.5 times the working pressure.

b) The negative pressure of the pipeline shall be restricted to 1/3 of atmosphere pressure or less.

The recommended solutions should include sensitivity checks to show that it is still valid with possible variations in system parameters such as wave speed, friction factor and system demands.

The Contractor shall submit the surge analysis report to the employer for approval. The report shall include computer analysis and graphs showing maximum and minimum transient pressure envelopes with and without surge protection devices. The report shall also include time-flow and time pressure plots at critical points with graphs and tables which shows surge control requirements shall be met by proposed measures.

8.36 Valves

(a) Valves shall be as per internationally recognized standards. Flanges shall be machined on faces and edges. Flanges shall conform to ISO 7005, IS 6392, BS EN 1092-1/ BS 4504.

(b) Valves shall be double flanged type and the faces shall be parallel to each other. The flange face should be at right angles to the valve centre line. Back side of valve flanges shall be machined or spot faced for proper seating of the head and nut.

(c) Valves buried or installed in underground chamber, where access to a hand wheel would be impractical, shall be operated by means of extension spindle and/or keys. Wherever extension spindle is provided, the valve shall also be provided with suitable headstock.

(d) Valve of diameter 450 mm and above shall be provided with lifting eyes and shall have detachable bolted covers for inspection, cleaning and servicing.

(e) Valve shall be suitable for frequent operation as well as operation after long periods of idleness in either open or closed position.

(f) The valve stem, thrust washers, screws, nuts and all other components exposed to the water shall be of a corrosion resistant grade of stainless steel.

(g) Valves shall be free from sharp projections which are likely to catch and hold stringy material.

(h) All the valve shall be of 10 bar rating.

(i) All the valves on the suction and delivery side of the Intermediate and Terminal sewage pumping station shall be of Motorized Knife gate type.

(j) All valves in the plant shall be provided with dismantling joint/Flexible joint/SS bellows for ease dismantling.

(k) All the valves on the suction and delivery side of the Primary sludge, Return & Waste Activated Sludge, Thickened Sludge, Centrifuge sludge feed, Digester sludge recirculation, Digester feed and

all sewage & sludge handling pumping system and for all sludge application in the plant shall be of Manually operated on suction side and Motorised Knife gate type on delivery side of the pump set.

(l) ISPS / TSPS Pumping main shall be installed with Kinetic Air valve with isolation sluice at High points and Sluice valve as Scour connection at Low points.

(m) All the valves shall be provided with Bypass valve arrangement 10% of main valve size.

(n) 2 sets of ladders shall be provided in the raw sewage pumping station to facilitate access of valves.

(o) Telescopic valves shall be provided in sludge storage tanks for sludge withdrawal purpose.

(p) All the sludge and chemical lines shall be installed with flushing connection with ball valves for maintenance.

(q) For all gas service and process air application the valve shall be Butterfly valves in Resilient seated (Bio Gas/Gas service) and Metal-Metal Seated (for process Air service).

8.36.1 Electric Actuator

(a) All local controls shall be protected by a lockable cover.

(b) Each actuator shall be adequately sized to suit the application and be continuously rated to suit the modulating control required. The gearbox shall be oil or grease filled, and capable of installation in any position. All operating spindles, gears and headstocks shall be provided with adequate points for lubrication.

(c) The valve actuator shall be capable of producing not less than 1½ times the required valve torque and shall be suitable for at least 15 minutes continuous operation.

(d) The actuator starters shall be integrally housed with the actuator in robustly constructed and totally enclosed weatherproof housing. The motor starter shall be capable of starting the motor under the most severe conditions.

(e) The starter housing shall be fitted with contacts and terminals for power supply, remote control and remote positional indication.

(f) Each starter shall be equipped as follows :
   (1) 2 No. Three phase magnetically operated line contactors with no-volt release and electrical and mechanical interlock.
   (2) 1 No. Three phase thermal cut-out device.
   (3) 1 No. Control circuit transformer fully protected by fuses on primary and secondary circuits.
   (4) 1 No. Set of “Open”, “Close” and “Stop” buttons.

(5) 1 No. Local- Off-Remote switches with padlocking facilities.
(6) 1 No. Set of torque and limit switches for “Open” and “Close” positions.
(7) 3 No. Sets of auxiliary limit switches in each direction.
(8) Valve position Analog Transmitter (i.e. Actuator accept To Read Analog signal from Actuator to PLC and also To Write Analog Signal from PLC to Actuator) & mechanical indicator and hand wheel for manual operation.
(9) Reduction gear unit
(10) Trip signals of Thermo switch, Torque Switch and Thermal Overload Relay shall be provided for Indication and also integrated to PLC.

8.36.2 Butterfly Valve

Butterfly valves shall be of double eccentric and resilient seated type generally as per BS EN 593 and IS 13095.

Butterfly valves shall be suitable for bi-directional pressure testing. The valves shall be of double flanged long type.

The valves shall be electrically/pneumatically/manual operated to suit the process requirement mentioned elsewhere in this tender document. The valve shall be free from induced vibrations. Valve shall be suitable for mounting in any position.

The valve seat shall be of metal to metal seated design for Process Air and Backwash Air application. All fasteners shall be set flush so as to offer the least resistance possible to the flow through the valve.

The shaft shall be stainless steel with Bronze or equivalent seal with self-lubricating bearings. Disc pins shall be stainless steel. Rings shall be bi-directional self-adjusting suitable for pressure or vacuum service. Valve shafts shall be a one-piece unit extending completely through the valve disc, or of the "stub shaft" type, which comprises two separate shafts inserted into the valve disc hubs.

All valve spindles and hand wheels shall be positioned to give good access for operational personnel. Valve of diameter 450 mm and above shall be provided with enclosed gear arrangement for ease of operation. The gear box shall be of worm and worm wheel design type, totally enclosed, grease filled and weather proof. The operation gear shall be such that they can be opened and closed by one man against an unbalanced head of 1.15 times the specified rating. Valve and gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 200 N. All hand wheels shall be arranged to turn in a clockwise direction to close the valve, the direction of rotation for opening and closing being indicated on the hand wheels.

Material of construction of valves shall comply with following requirement:

Component	**Material**
Body	SG Iron IS 1865 Gr. 500/7/GGG50 or 400/15/GGG40
Disc	SG Iron IS 1865 Gr. 500/7/GGG50 or 400/15/GGG40
Shaft	Stainless Steel; ASTM A 276 Gr. 431/420
Body Seat	Stainless Steel ASTM A 276 Gr.316/ CF8M
Bearing	Stainless Steel/Bronze backed Teflon
Disc seat	Stainless Steel ASTM A 276 Gr. Gr.316/ CF8M
Body seat	Stainless Steel; ASTM A 743 CF8M
Internal Fasteners	SS 316
External Fasteners	SS316

The disc shall be designed to withstand the maximum pressure differential across the valve in either direction of flow. The disc shall be contoured to ensure the lowest possible resistance to flow and shall be suitable for throttling operation.

Valves shall be capable of closing against the maximum flow that can occur in system. The shaft shall be designed to withstand the maximum torque that will be imposed by the operator. It shall be secured to the discs by tapered stainless steel cotter pins.

Valves shall be provided with position indicator to show the position of the disc, mounted on the driven shaft end.

Rigid adjustable stop mechanism shall be provided within the gear box or elsewhere on the valve to prevent movement of the disc beyond the fully open or closed position (i.e. set points).

8.36.3 Sluice Valve

(a) Sluice valve shall generally confirm to IS 14846.

(b) Sluice valves shall be of non-rising spindle type. The valve shall be furnished with a bushing arrangement for replacement of packing without leakage.

(c) Valves of 400 mm and above shall be provided with thrust bearing arrangement for ease of operation.

(d) Valves of diameter 400 mm and above shall be provided with enclosed gear arrangement for ease of operation. The operation gear of all valves shall be such that they can be opened and closed by one man against an unbalanced head 15% in excess of the maximum specified rating. Valve and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 400 N.

(e) All valves, spindles and hand wheels shall be positioned to give good access for operational personnel.

(f) All the hand wheels shall be arranged to turn in a clockwise direction to close the valve. The direction of rotation for opening and closing of the valve shall be indicated on the hand wheels.

(g) The material of construction of valve shall be as follows:

Component	**Material**
Body / Dome / Bonnet	SG Iron IS 1865 Gr. 500/7/GGG50 or 400/15/GGG40
Wedge	SG Iron IS 1865 Gr. 500/7/GGG50 or 400/15/GGG40
Spindle	Stainless Steel; ASTM A 276 Gr. 431 S29 /420
Thrust collar & Wedge Nut	Bronze: IS:318 Gr LTB2
Seals	Food Grade EPDM
O-Rings	NBR
Seat / face Rings	Bronze IS 318 Gr. LTB 2/SS 316
Back Seat Bush	Bronze IS 318 Gr. LTB2/SS 316
Shoe and Channel lining	Bronze IS 318 Gr. LTB2/SS 316
Internal Fasteners	SS 316
External Fasteners	SS 316
Gear, Gear housing	Cast Steel ASTM A 216 Gr. WCB

8.36.4 Knife Gate Valves

Design & Construction Details:

The Knife gate valves shall be manufactured generally as per the latest AWWA C520-10 standards.

Other constructional features and details of components of the required valves are to be as under:

The valve body should be of ductile iron construction as specified. The valve should be provided with gate made of stainless steel of grade as specified and the gate should have beveled knife edge at the bottom to cut through and easily enter in the solids settled in the bottom and ensure positive shut-off / closure in sewage environment.

The Valve should be designed for sealing in uni-directional flow application.

The valve should be provided with replaceable type flexible sealing arrangement to offer drop tight shut off. The seals should be made of EPDM rubber and should be held in place by an easily removable type seal retainer ring. The seals should be mechanically retained in place in a machined groove on the face of seal retainer ring. The sealing system should be field replaceable at site.

The valve housing should have integral as cast tapered lugs provided for pushing the gate towards the flexible rubber seal only at the verge of closure with a view to avoid seal wear and achieve drop tight shut off. The surface of the gate coming in contact with the seal should be polished & buffed.

The bonneted valves shall have glandless design to avoid repeated tightening / replacement of gland packing. The stuffing "O" ring seal should be pressurized by thrust washer from both the sides and should be pressurized / tighten by thrust retainer nut.

The packings should be of graphited synthetic yarn to reduce the friction and offer higher life. Provision shall be made to enable tighten the gland packing by means of a pusher arrangement to minimize the leakage through the back of the valve. Replacement of gland packings should be possible in installed condition of the valve without there being line pressure.

The spindle should be double start / single threaded and non-rising type for compact & safe operation. Gate opening indicating arrangement should be provided to find out the extent of gate opening /closing. The operation of the valves shall be manual / motorized as specified elsewhere in the tender specification.

In case the valve is to be operated from a far then it shall be provided with joining couplings, extension spindle, spindle guides and mounting pedestal with suitable anchor bolts / anchor fasteners on the platform.

Materials of construction:

Component	Material
Body	: Ductile iron (SG) IS 1865 Gr.400/12
Seal Retainer ring	: Stainless steel to ASTM A-351 Grade CF8M
Inlet Seal / Rubber Seals / O rings	: EPDM Rubber
Knife gate	: Stainless Steel ASTM A 240 type 316
Spindle	: Stainless Steel ASTM A 276 type 316
Assembly bolts, nuts and fastener	: Stainless Steel ASTM A 276 type 316
Spindle nut	: Gunmetal / Phosphor Bronze / Brass
Bracket / Adapter plate	: Mild Steel to IS: 2062 grade A, Epoxy Painted
Packing	: Graphited synthetic yarn

8.36.5 Slide Gate Valve

(a) Valve shall be of wafer type with elastomer body sealing arrangement for bi-directional shut-off. The valves shall be designed to allow gland repacking without relieving line pressure.

(b) Body shall be two-piece cast construction bolted together with a mid-flange.

(c) The elastomer body seal shall be held in body such that it is kept away from direct impingement of any particles in the flow medium.

(d) The gate shall be provided with a bevelled edge to facilitate positive closure of valve even with contaminated area.

(e) The body internals shall be countered such that settlement of particles in the media.

(f) Purge connection shall be provided optionally for these valves for cleaning the seating area.

(g) The material of construction of valve shall be as follows :

S. No.	Component	Material
(i)	Body	SG Iron IS 1865 Gr. 500/7/GGG50 or 400/15/GGG40
(ii)	Gate	Stainless Steel: BS:970 Gr. 316
(iii)	Stem	Stainless Steel: BS:970 Gr. 316
(iv)	Body seal	Stainless Steel: BS:970 Gr. 316
(v)	Hand wheel	Cast Iron: IS: 210 FG Gr. 260

8.36.6 Non Return Valve

(a) Type of Valve:

- For Raw Sewage, Clear water & Sludge Application: Only Swing type non return valve complying to IS 5312 is accepted for the individual delivery line & Common header of the pump. Swing door valves of size 600mm and above shall be of Multidoor type.

- For Process Air Application: Only Flap type non return valve is accepted for the individual delivery line & Common header of the Air Blower.

(b) The valves shall be suitable for mounting on a horizontal pipeline and flow direction shall be clearly embossed on the valve body. Hydraulic passages and doors shall be designed to avoid cavitation.

(c) Valves shall possess high speed closing characteristics and to be designed for minimum slam condition when closing.

(d) Valve of diameter greater than 450 mm shall be provided, in addition to others, supporting feet and jacking screws. Hinge pins / shaft shall preferably be square in section to ensure positive location of flaps and provide for secure fixing.

(e) Maximum pressure drop across the valve shall be 0.4 mwc. Maximum allowable leakage rate shall be 7cc/hr/mm diameter.

The material of construction of valve shall be as follows:

S. No	Component	Material
1.	Body and Doors/ with hinge and diaphragm	SG Iron IS 1865 Gr. 500/7/GGG50 or 400/15/GGG40
2.	Hinge pin/Shaft	Stainless Steel; ASTM A 276 Gr. 431 /420/410
3.	Seat / Face rings	Stainless Steel: ASTM A 743 CF8M / Integral Nickel-chromium overlay welding and micro finished
4.	Bearings Bush	Stainless Steel backed Teflon
5.	Shaft bearing	Bronze IS 318 Gr. LTB 2
6.	Internal & External Fasteners	SS 316

8.36.7 Telescopic Valves

The telescopic valve shall be a proprietary item of proven design manufactured in cast iron and adjustable to cater for variation in level.

The bell mouth height shall be controlled by a hand wheel operated from top of the chamber.

The bell mouth, pipe work, spindle and headstock shall be robustly constructed with adequate brackets of cast iron.

The bell mouth shall be connected by swept tees to a cast iron sludge outlet pipe of suitable diameter.

Component	Material
Bell Mouth	Cast Iron: IS:210 Gr. FG 260
Piping	Cast Iron: IS:210 Gr. FG 260
Spindle	Stainless Steel Gr. 304
Hand wheel	Cast Iron: IS:210 Gr. FG 260

8.36.8 Diaphragm Valves

Diaphragm valves shall be of the full-bore type to suit the maximum working pressure ratings required. Body ends shall be flanged and drilled to BS EN 1092-1.

Indicators shall be supplied where specified showing both OPEN and CLOSED positions shall be supplied and provisions made for initiating the operation of remote indicator lights in the fully OPEN and CLOSED positions.

Valves used for toxic or hazardous fluids shall be provided with an additional `O' ring seal of nitrite rubber or other approved material.

Diaphragms shall be composed of moulded reinforced, flexible material attached by studs to the compressor. Diaphragm materials shall, where required, be composed of corrosion resistant material.

8.36.9 Isolating Cocks

For isolation of small bore pipe work tapings for instrumentation equipment etc., and for individual component isolation, the cocks shall be stainless steel, 0.25 turn ball or plug valve with the operating handle arranged to indicate the open and closed positions. Where specified, means shall be provided for securing the valve body to a front panel or near surface.

8.36.10 Pressure / Vacuum relief valves

Pressure relief valves shall be capable of relieving pressure in the system to prevent the system being pressurized in excess of a preset maximum allowable pressure. The valves shall be drops tight under no flow conditions.

Vacuum relief valves shall be capable of preventing the vacuum pressure to be developed in the system by allowing air entry. The valves shall be drops tight under no flow conditions.

The valve operation shall be achieved by the interaction of the inlet pressure and an intermediate pressure produced by a pilot valve or relay system acting on the upper side of the main valve.

The pilot valve or relay system shall be actuated by a diaphragm connected to the inlet pressure on its underside and a constant pressure on its upper side derived either from weights or from a spring.

Body ends shall be flanged and drilled to BS EN 1092-1.

8.36.11 Adjustable Weir Plates

The adjustable weir plates shall be manufactured from 3 mm thick SS 304 Plates and to the approval of the Employers Representative.

Weir plates shall be complete with fixing nuts, bolts and washers and suitable for a total vertical adjustment of 100 mm through SS304 clamping plates. Fixings shall be designed for ease of accurately

leveling the plates, securing the plates, and shall enable the plates to be adjusted during the life of the Works to accommodate differential settlement of the structure.

8.36.12 Eccentric Structure Valve

(a) Valve shall be eccentric structure or horseshoe type disc and body. The valve shall be used for sludge line and flow control.

(b) The valves shall be for a smooth flux of fluid and suitable for fluid contained sludge and impurities at the treatment plant.

(c) The material of construction of valve shall be as follows:

S. No.	Component	Material
(i)	Body	Ductile (SG) Iron: IS 1865 Gr.500/7
(ii)	Disc	Ductile (SG) Iron: IS 1865 Gr.500/7 with rubber lining
(iii)	Stem	Stainless Steel: BS:970 Gr 304
(iv)	Hand wheel	Cast Iron: IS:210 Gr FG 260

8.36.13 Air Valves

(a) The air valve must be of the type that incorporates a kinetic and an automatic air release valve in one unit. It should be able to release air (gases) and to admit air into the sewage line, when the line is emptied.

(b) The air valve must guarantee complete separation of liquid sewage from the sealing system of the air valve under all working conditions.

(c) The air valve must have arrangement for draining and flushing by external water.

(d) All sealing mechanism system parts of the air valve should be made of stainless steel-316.

(e) The body of the valve should be such as to minimise the accumulation of sewage deposit at the bottom of the coating or of cast iron. The valve mechanism must be such as to prevent opening of the air valve upon every slight pressure change in line. Air Valve shall be Epoxy powder coating shall be provided inside and outside.

(f) Each air valve must be supplied with a sluice vale for isolation for maintenance purpose.

Component	Material
Body/Top Cover	Ductile Iron Gr. GGG40/ GGG-50

Small orifice Plug	Leaded Tin Bronze IS 318 Gr. LTB 2/SS 316
Seat Ring	Leaded Tin Bronze IS 318 Gr. LTB 2/ SS 316
Float/Balls	SS AISI 304/ Polycarbonate
Cover Bolts	Austenitic alloy steel/SS 304
Gaskets & Seals	Food Grade EPDM

8.37 Domestic Water Pump sets

The Pump shall be of Centrifugal type, self-priming and monoblock type. All the necessary piping with union, bends and tees shall be provided. Suction and discharge isolation valves and non-return valves on the discharge side shall be forged steel. Piping shall be as per IS: 1239 heavy class.

8.38 Approved Vendor/Manufacturer/Make List-Mechanical Equipment

The naming of a manufacturer in this specification is not intended to eliminate competition or prohibit qualified manufacturers from offering equipment. Rather, the intent is to establish a standard of excellence for the material used, and to indicate a principle of operation desired.

	CONSOLIDATED Mechanical Equipment VENDOR LIST	
S.NO.	**ITEM DESCRIPTION**	**APPROVED VENDOR/ MANUFACTURER/ MAKE**
1	Air Compressor	M/s Ingersoll Rand
		M/s Kaeser
		M/s Kirloskar Pneumatics
		M/s Atlas Copco
		M/S-Chicago Pneumatics
		M/S - Elgi Compressor
2	Air Blowers (Roots Type)	M/s Swam Pneumatics
		M/s Everest
		M/s TMVT Industries
		M/s ACME Air Equipments
		M/s Usha compressors
3	Chlorination System	M/s Industrial Device
		M/s Pennwalt
		M/s Rite Water

	CONSOLIDATED Mechanical Equipment VENDOR LIST	
S.NO.	**ITEM DESCRIPTION**	**APPROVED VENDOR/ MANUFACTURER/ MAKE**
		Solutions
		M/s Chloro Tech
		M/s Capital Controls
		M/s Zion Technology
4	Cranes (EOT, Hoists, Jib cranes)	M/s Brady & Morris
		M/s Eddy Cranes
		M/s Safex Electromech
		M/S - Hercules Hoists Ltd.
		M/S - Avon Cranes
		M/S - Reva
		M/S - Wester
5	Centrifuge Decanter	M/s Pennwalt
		M/s GEA Westfalia
		M/s Andritz
		M/s Hiller
		M/s Alpha Laval
6	Exhaust Fans	M/s Alstom
		M/s Howden
		M/s Bajaj
		M/s Marathon
		M/s Crompton
		M/s Almonard
7	Flash Mixer/ Agitator	M/s Fibre & Fibre
		M/s Ceecons
		M/s Triveni Engineering
		M/s Remi Process
		M/s Milton Roy
		M/s Shivpad
8	Horizontal/Vertical Centrifugal Pumps	M/s KBL
		M/s Wilo /Mather &

	CONSOLIDATED Mechanical Equipment VENDOR LIST	
S.NO.	**ITEM DESCRIPTION**	**APPROVED VENDOR/ MANUFACTURER/ MAKE**
		Platt
		M/s KSB
		M/s Grundfos
		M/s WPIL
		M/s Pentair
		M/s Sam Turbo machinery
		M/s Xylem
		M/s Andritz
	Submersible Pumps	M/s KSB
		M/s Xylem
		M/s Wilo
		M/s WPIL
		M/s ABS Sulzer
		M/s Grundfos
		M/s Kishor
	Submersible Pumps-Tube installed	M/s ABS Sulzer
		M/s Xylem
		M/s WPIL
		M/s Wilo
		M/s Grundfos
		M/s KSB
	Progressive Cavity Screw Pumps	M/s Rotomac Pumps
		M/s Nestzch Technology
		M/s PD Pumps
		M/s UT Pumps
		M/s Tushaco Pumps
		M/s Positive Metering Pumps
		M/s Roto Pumps

	CONSOLIDATED Mechanical Equipment VENDOR LIST	
S.NO.	**ITEM DESCRIPTION**	**APPROVED VENDOR/ MANUFACTURER/ MAKE**
9	Chemical Dosing Pumps	M/s Milton Roy
		M/s Prominent
		M/s Heidelberg
		M/s Positive Metering Pumps
		M/s Swelore Engineering
		M/s SR Metering Pumps
10	Submersible Mixer	M/s ABS-Sulzer
		M/s Grundfos
		M/s KSB
		M/s ITT FLYGT-Xylem
11	Clarifiers and Thickener Mechanism	M/s Voltas
		M/s Triveni
		M/s Shivpad
12	Vortex type Grit Removal Mechanism	M/s Triveni
		M/s Jhonson (Acceptance)
		M/s Estragua
		M/s OVIVO
		M/s Huber
		M/s Smith & Loveless
13	Butterfly Valve	M/s Pentair
		M/s Fouress
		M/s VAG Valves
		M/s Hawle
		M/s Indian Valve Company
		M/s AVK Valves
		M/s KBL

	CONSOLIDATED Mechanical Equipment VENDOR LIST	
S.NO.	**ITEM DESCRIPTION**	**APPROVED VENDOR/ MANUFACTURER/ MAKE**
14	Sluice Valve for Sewage Application	M/s VAG
		M/s KBL
		M/s AVK Valves
		M/s Jupiter Valves
		M/s Indian Valve Company
15	Non-Return Valve for Sewage Application	M/s VAG
		M/s KBL
		M/s AVK Valves
		M/s Jupiter Valves
		M/s Indian Valve Company
15	PP Valve	M/s Shenco
		M/s U N Poly valves
		M/s George Fischer
		M/s Beaver Process Equipment
16	Penstock Gates	M/s Jash
		M/s Durga Valves
		M/s Yashwant
17	M.S- Plates	M/s Jindal
		M/s TATA
		M/s Sail
18	Stainless Steel Pipes	M/s SAIL
		M/s Jindal
		M/s. Remi Pipes
		M/s Roopam Steel
		M/s Ratnamani
19		M/s TATA Pipes

	CONSOLIDATED Mechanical Equipment VENDOR LIST	
S.NO.	**ITEM DESCRIPTION**	**APPROVED VENDOR/ MANUFACTURER/ MAKE**
	GI Pipes	M/s Jindal Pipes
		M/s Surya Pipes
20	DI Pipe & DI Pipe Fittings	M/s Kiswok (For Fittings Only)
		M/s Kejriwal Castings
		M/s Jindal Saw
		M/s Electrotherm
		M/s Jupiter (For Fittings Only)
		M/s Electro steel Castings
21	Chlorine Tonners	M/s ISGEC
		M/s Meenakshi Associates
22	Fine Bubble Diffusers	M/s Environmental Dynamics
		M/s OTT GMBH
		M/s Rehau Polymer
		M/s SSI Aeration
23	Centrifugal Air Blowers	M/s ABS Sulzer
		M/s Siemens
		M/s Turbomax
		M/s Neuros (Usha Neuros)
		M/s Aerzen
24	Coarse, Medium Bar Screen type/Trash Rake Bar Screen	M/s Jash Engineering
		M/s Jhonson (Aqseptence) screens
		M/s Huber
25	Electric Actuators	M/s Auma
		M/s Limitork

	CONSOLIDATED Mechanical Equipment VENDOR LIST	
S.NO.	**ITEM DESCRIPTION**	**APPROVED VENDOR/ MANUFACTURER/ MAKE**
		M/s Rotork
26	Fine Screen (Mesh/ Punched hole type)	M/s Estragua
		M/s Huber
		M/s OVIVO
		M/s Jash Engineering
27	Solid Grabbing Unit	M/s Estragua
		M/s OVIVO
		M/s Jash Engineering
		M/s Jhonson (Aqseptence) screens
28	Rectangular Clarifier (Chain & Flight Mechanism)	M/s Finnchain
		M/s Evoqua
		M/s Dewa
29	Ultrafiltration System	M/s Koch Membrane
		M/s Toray
		M/s Veolia Water
		M/s Dupont
30	Pre-Treatment Combi Unit	M/s Jhonson (Aqseptence) screens
		M/s Estragua
		M/s Huber
31	Solar Sludge Dryer unit	M/s Huber
		M/s SFC Technologies
32	Pneumatic Actuators	M/s Rotex
		M/s D Torque
		M/s Elomatic
33	Double Wall Corrugated (DWC) HDPE Pipes	M/s Jain Irrigation
		M/s Alom Extrusions
		M/s Prince
		M/s Supreme
		M/s Jagannath Industries

	CONSOLIDATED Mechanical Equipment VENDOR LIST	
S.NO.	**ITEM DESCRIPTION**	**APPROVED VENDOR/ MANUFACTURER/ MAKE**
34	Motors	M/s Crompton Greaves Ltd
		M/s Marathon Electric (Alstom)
		M/s GEC
		M/s Siemens
		M/s Kirloskar Electric company
		M/s Bharat Bijlee Ltd
		M/s ABB
		M/s-TOSHIBA
35	Ball Valves	M/s BDK Engineers
		M/s Flowchem
		M/s Virgo
		M/s Hawa Valves
		M/s KBL
		M/s GM Valves
		M/s Micro finish
36	Knife Gate valves	M/s Jash Engineering (Scheutte)
		M/s Bray
		M/s Fouress
		M/s KBL
		M/s VAG
		M/s AVK
37	Air Valves	M/s KBL
		M/s ARI Valves
		M/s Jupiter Valves
		M/s Indian Valve Company
		M/s VAG Valves
		M/s AVK Valves

	CONSOLIDATED Mechanical Equipment VENDOR LIST	
S.NO.	**ITEM DESCRIPTION**	**APPROVED VENDOR/ MANUFACTURER/ MAKE**
38	Diaphragm valves	Crane Process
		Micro finish
		BDK Engineers
		Leader
39	Eccentric Plug valves	M/s Dezurik
		M/s Emerson
		M/s Viking Jhonson
40	Disc Filtration System	M/s Hydro Tech
		M/s Xylem
		M/s Estragua
		M/s Jash Invent
		M/s Huber
		M/s Aqua Aerobics
		M/s Evoqua water Technologies
41	Air conditioner	M/s Bluestar
		M/s Samsung
		M/s Voltas
		M/s Mitsubishi
42	Vacuum Pump	M/s - Kirloskar Brothers Ltd.
		M/s - Slm Manek Lal Industries Ltd.
43	Metering Pumps	M/s Swelore
		M/s Milton Roy
		M/s Prominent
		M/s Positive Metering Pumps
		M/s SR Metering Pumps
		M/s Dover India Ltd
		M/s JEW
		M/s Matz
44	Weigh Bridge	M/s - Vishwa Karma

	CONSOLIDATED Mechanical Equipment VENDOR LIST	
S.NO.	**ITEM DESCRIPTION**	**APPROVED VENDOR/ MANUFACTURER/ MAKE**
		M/s - Avery India Ltd.
45	Fire Extinguishers	M/s - Steelage Industries
		M/s - Vijay Fire Protection System Pvt. Ltd.
		M/s –Safex Fire Services Ltd.
46	Caustic Pump	M/s - Rajedia,
		M/s - Antico,
		M/S – Investa
47	FRP Centrifugal Air Blower	M/S - Supreme Plastic,
		M/S - Nufibrotech,
		M/S - BSF
		M/S - Patel Air Flow
48	UPVC & HDPE Pipes	M/s Jain Irrigation
		M/s Finolex
		M/s Duraline
		M/s Manikya Palstichem
		M/s Pennwalt Agro
		M/s - Astral
		M/s - Ashirwad
		M/s - Prince
		M/s - Supreme
49	Basket Type Strainer/Self Cleaning online Filters for UF system	Amiad filter
		STF Filters
		Filter Concept

All the equipment, to be supplied under this contract has to be from experienced manufacturer. The equipment of only those manufacturers, who have sufficient proven experience of manufacturing the respective equipment of similar capacity, shall be considered.

Note-1: In order to achieve standardization for appearance, operation, maintenance, spare parts and manufacturer's service, like items of equipment provided hereunder shall be the end products of one (1) manufacturer.

Note-2: In the event that the contractor wishes to propose alternate makes for the equipment mentioned above, he shall submit the following during detailed engineering:

1) Demonstrate that the proposed makes are "equivalent " to the approved makes. The contractor shall ensure that alternate makes proposed, shall comply completely to the tender specifications, before the same is submitted for approval.
2) Submit ISO certificates for the OEM.
3) Submit quality certificates that the equipment adheres to, as required under this contract.
4) Submit product brochures for the proposed equipment, with information on spares availability and service setup in employer's country.
5) Manufacturer involved in manufacture of specified proposed equipment for at least 10 years before bid date
6) End user performance certificates for minimum 5 successful individual installations of similar size or capacity as per this contract with the proposed equipment and model no, commissioned and satisfactorily operating for at least 5 years before bid date.
7) Manufacturer to provide full contact information for each reference as part of submission.

And the above qualities and requirements shall be demonstrated and evidenced by inspection of manufacturing units and successfully installed plants (at the End users plant/premises) for the equipment's desired and successful operation and certification by the Employer/Engineer (BWSSB)/Representative.

The Employer shall reserve the right to accept or reject the Bidder proposed makes of Equipment.

8.39 Warranty

- Comply with the requirements of each type of Equipment and specification mentioned elsewhere in this document.
- Warrant all components to be free of defects in materials or workmanship for 12 months from date of Taking Over Certificate.
- Individual warranties by component manufacturer in lieu of single source responsibility by the main Equipment manufacturer shall not be acceptable.
- Items which fail during the warranty period, excluding expendable items, shall be replaced without cost to the Employer.
- Provide manufacturer's guarantee and warranty certificates prior to equipment start-up.

8.40 Pipelines, Pipe work and Fittings

8.40.1 Applicable codes

The following codes and standards unless specified herein shall be referred to, or equivalent to the approval of Engineer. All the Pipe material shall be as per IS/BS/JIS standards.

8.40.2 Materials

IS : 210	Specification for grey iron casting
IS : 290	Specification for coal tar black paint
IS : 456	Code of practice for plain and reinforced concrete
IS : 458	Specification for pre-cast concrete pipes (with and without reinforcement)
IS : 516	Method of test for strength of concrete
IS : 638	Specification for sheet rubber jointing and rubber insertion jointing
IS : 783	Code of practice for laying of concrete pipes
IS : 816	Code of practice for use of metal arc welding for general construction in mild steel
IS : 1367	Technical supply conditions for threaded steel fasteners
IS : 1387	General requirements for the supply of metallurgical materials
IS : 1500	Method for Brinell hardness test for metallic materials
IS : 1536	Specification for centrifugally cast (spun) iron pressure pipes for water, gas and sewage
IS : 1537	Specification for vertically cast-iron pressure pipes for water, gas and sewage
IS : 1538	Specification for cast iron fittings for pressure pipes for water, gas and sewage
IS : 1916	Specification for steel cylinder pipes with concrete lining and coating
IS : 2078	Method for tensile testing of grey cast iron
IS : 3597	Method of tests for concrete pipes
IS : 3658	Code of practice for liquid penetrant flow detection
IS : 5382	Specification for rubber sealing rings for gas mains, water mains and sewers
IS : 5504	Specification for spiral welded pipes
IS : 6587	Specification for spun hemp yarn
IS : 7322	Specification for specials for steel cylinder reinforced concrete pipes

8.40.3 Code of Practice

IS : 783	Code of practice for laying of concrete pipes
IS : 3114	Code of practice for laying of cast iron pipes
IS : 3764	Excavation work - Code of Safety
IS : 4127	Code of practice for laying of glazed stoneware pipes
IS : 5822	Code of practice for laying of electrically welded steel pipes for water supply.
IS : 6530	Code of practice for laying of asbestos cement pressure pipes.

8.40.4 Materials for Pipelines

Each pipeline shall be constructed in a material compatible with the fluid conveyed through that pipeline, i.e. the materials used in the pipes which are or can be in contact with the untreated or treated sewage, shall not contain any matter which could impart taste or odor or toxicity or otherwise be harmful to health or adversely affect the sewage conveyed. Nor shall any pipe be adversely affected by the fluid being conveyed through that pipe.

Pipe work and valve materials for the following duties shall be as follows or equivalent to the approval of the Engineer:

Table 8.1 Pipe work and Valve Materials

Application / Location	Material
Chlorine: Drum connections	Cadmium plated 70/30 copper nickel CN 107, BS 2871: Part 1
Chlorine gas or liquid	flanged or welded carbon steel, CAF flanged joints
Chlorine gas lines below atmospheric pressure	Polyvinylidene fluoride (PVDF) with solvent welded or flanged joints/ Class E UPVC in concrete covered ducts outside building.
Chlorine solution	Inside building and in exposed areas, rubber lined carbon steel Valves shall be globe type with forged steel bodies, monel spindles, stainless steel seats and PTFE gland packing or carbon steel, monel plug, PTFE sleeved plug
Polyelectrolyte & Alum dosing line	UPVC/HDPE/HDPE (High density polyethylene) PVC with 10 Kgf/cm2
Sewage Raw Sewage, Process sewage, dirty waste water, supernatant and treated Sewage/Effluent, Process sludge	Mild steel with mortar lining/Guniting (Beyond 1200mm diameter of pipe) or Ductile Iron (Up to 1200mm) K9 class.
Service water	UPVC/HDPE (below 100 mm), ductile iron (100 mm and above).
Process Air	Blower individual delivery and common header shall be Stainless steel AISI 304 (Schedule 10). After Common header, Aeration tank top of platform and piping entering aeration tank and individual drop legs of diffusers shall be of Stainless steel AISI 316 (Schedule 10) for exposed or buried service and for submerged service.
Digester Gas	SS304 Schedule 10 for Header and distribution pipe at top of digester, interconnection pipes in the plant shall be to SS304 sch10

8.40.5 Ductile Iron Pipes and Fittings

8.40.5.1 Pipes and Fittings

(a) General

Ductile iron pressure pipes and fittings (Class K9) shall comply with IS 8329 and IS 9523. All fittings shall be socketed unless specified otherwise.

(b) Materials

The materials used in the manufacture pipes and fittings shall comply with IS 8329 and IS 9523.

(c) Tests

Tests on pipes and fittings shall be carried out in accordance with IS 8329 and IS 9523. The test method shall be submitted for approval of Engineer.

The Engineer shall be permitted free access to the place of manufacture for the purpose of examining, inspection and witnessing the testing of pipes and fittings.

8.40.5.2 Joints

(a) Spigot and Socket Joints

These shall have sockets which are integral with the pipe and incorporate an elastomeric rubber ring gasket conforming to IS: 5382 (Latest edition/revision with amendments, if any).

(b) Flanged Joints

These shall comply with dimensions and drilling details shall be to BS EN 1092-1/BS: 4504 Table10/11 and16/11. All flanged joints between steel and ductile iron pipe work shall be electrically isolated joints. These shall have isolation gaskets between the flanges, isolation sleeves around all bolts and isolation washers under all bolt heads and nuts. All materials shall be supplied by a specialist manufacturer and be to the approval of the Engineer.

8.40.5.3 Linings

Ductile iron pipes and fittings shall have a cement mortar lining, in accordance with IS 11906 or ISO 4179.

Pipe linings shall be inspected on site and any damage or defective areas made good to the satisfaction of the Engineer. The Contractor may use specialist mortars, mortar additives or curing agents only with the approval of the Engineer.

Certain sections are amplified as follows:

No additives shall be used without the written approval of the Engineer, and shall be used strictly in accordance with the manufacturer's recommendations.

The minimum thickness of the lining at one point shall not be less than 4 mm or as per IS 8329.

8.40.5.4 Coating

(a) General

Ductile iron pipes and fittings shall be zinc coated with bitumen over coating, all in accordance with the following Specifications. Pipe coatings shall be inspected on site and any damage or defective areas made good to the satisfaction of the Engineer.

(b) Zinc Coating

Zinc coating shall comply with ISO 8179 and shall be applied as a spray coating. The mass of sprayed metal shall not be less than 130 g/m^2 as described in Clause 5.2 of ISO 8179.

(c) Bitumen Coating

Bitumen coating shall be of normal thickness 0.07 mm unless otherwise specified. It shall be a cold applied compound complying with the requirements of BS 3416 Type II, suitable for tropical climates, factory applied in accordance with the manufacturer's instructions.

Damaged areas of coating shall be repainted on site after removing any remaining loose coating and wire brushing any rusted areas of pipe.

(d) Polythene Sleeving

Where polythene sleeving is specified (generally for all buried DI pipes need sleeve covering) to be applied in addition to bitumen coating it shall comply with ISO 8180. Site applied sleeving shall be stored under cover, out of direct sunlight, and its exposure to sunlight shall be kept to a minimum. Pipes having a factory applied sleeving must be stored in the same conditions.

8.41 Reinforced Cement Concrete Pipes

8.41.1 Design

Design of RCC pipes including reinforcement details and the ends of pipes shall be in accordance with the relevant clauses of IS: 458.

Manufacturing

General

The method of manufacture shall be such that the form and the dimensions of the finished pipes are accurate within the limits specified in relevant clause of IS: 458. The surfaces and edges of the pipes shall be well defined and true, and their ends shall be square with the longitudinal axis. The ends of the pipes shall be further reinforced by an extra ring of reinforcement to avoid breakage during transportation.

The RCC pipes and collars/rubber rings shall be systematically checked for any manufacturing defects by experienced supervisors so as to maintain a high standard of quality.

The Engineer shall at all reasonable times have free access to the place where the pipes and collars/rubber rings are manufactured for the purpose of examining and testing the pipes and collars/ rubber rings and of witnessing the test and manufacturing.

All tests specified either in this Employer's Requirements or in the relevant Indian standards shall be performed by the supplier/contractor at his own cost and in presence of the Engineer if desired. For this, sufficient notice before testing of the pipes and fittings shall be given to the Engineer.

If the test is found unsatisfactory, the Engineer may reject any or all pipes of that lot. The decision of the Engineer in this matter shall be final and binding on Contractor and not subject to any arbitration or appeal.

8.41.2 Materials

For all materials Factory's test result, and written guarantee document with necessary analysis data shall be submitted to obtain the approval of the Engineer before carrying to sites.

(a) Cement

Cement shall be used for the manufacture of sulphate resistant cement RCC pipes and collars shall conform to relevant IS codes. The use of pozzolana as an admixture to Portland cement shall not be permitted.

(b) Aggregates

Aggregates used for the manufacture of RCC pipes and collars shall conform to IS: 383. The maximum size of aggregate should not exceed one third the thickness of the pipe or 20mm, whichever is smaller.

(c) Mixing and Curing Water

Water shall be clean, Colour less and free from objectionable quantities of organic matter, alkali, acid, salts, or other impurities that might reduce the strength, durability or other desirable qualities of concrete and mortar. Contractor shall submit water quality report before using it.

(d) Reinforcement

Reinforcement used for the manufacture of the RCC pipes and collars shall be mild steel Grade I or medium tensile steel bars conforming to IS: 432 (Part-1) or hard-drawn steel wire conforming to IS: 432 (part-2). Reinforcement cages for pipes and collars shall be as per relevant requirement of IS:458.

(e) Concrete

Concrete used for the manufacture of RCC pipes and collars shall conform to IS: 456. The minimum cement content and minimum compressive strength of concrete shall be as per relevant requirements of

IS: 458. Compressive strength tests shall be conducted on 15 cm cubes in accordance with the relevant requirements of IS: 456 and IS: 516.

(f) Curing

Pipes manufactured in compliance with IS: 458 shall be either water cured or steam cured in accordance with the relevant requirements of IS: 458.

(g) Dimensions

The internal diameter, wall thickness and length of barrel and collar of pipes, reinforcement (longitudinal and spiral), type of ends and minimum clear cover to reinforcement and strength test requirements shall be as per the relevant clauses / tables of IS:458 for different classes of pipes.

The tolerances regarding overall length, internal diameter of pipes or sockets and barrel wall thickness shall be as per relevant clause of IS: 458.

(h) Workmanship and Finish

Pipes shall be straight and free from cracks. The ends of the pipes shall be square with their longitudinal axis so that when placed in a straight line in the trench no opening between ends in contact shall exceed 3 mm in pipes upto 600mm diameter (inclusive), and 6 mm in pipes larger than 600 mm diameter.

The outside and inside surfaces of the pipes shall be smooth, dense and hard, and shall not be coated with cement wash or other preparation unless otherwise agreed to between the Engineer and the manufacturer or supplier.

The pipes shall be free from defects resulting from imperfect grading of the aggregate, mixing or moulding.

The pipes shall be free from local dents or bulges greater than 3 mm in depth and extending over a length in any direction greater than twice the thickness of barrel.

The deviation from straight in any pipe throughout its effective length, tested by means of rigid straight edge parallel to the longitudinal axis of the pipe shall not exceed, for all diameters 3 mm for every meter run.

(i) Testing

All pipes for testing purposes shall be selected at random from the stock of the manufacturer and shall be such as would not otherwise be rejected under the criteria of tolerances as mentioned in IS 458. Engineer reserve the right to attend all testing.

During manufacture, tests on concrete shall be carried out as per IS: 456. The manufacturer shall supply, when required to do so by the Engineer the results of compressive tests of concrete cubes and split

tensile tests of concrete cylinders made from the concrete used for the pipes. The manufacturer shall supply cylinders or cubes for test purposes required by the Engineer and such cylinders or cubes shall withstand the tests prescribed as per IS 458. Every pressure pipe shall be tested by the manufacturer for the hydrostatic test pressure. For non-pressure pipes, 2 percent of the pipes shall be tested for hydrostatic test pressure.

The specimen of pipes for the following tests shall be selected in accordance with relevant clause of IS: 458 and tests in accordance with the methods described in IS: 3597.

i) Hydrostatic test
ii) Three edge bearing test
iii) Absorption test
iv) Visual Examination

(j) Sampling and Inspection

In any consignment, all the pipes of same class and size and manufactured under similar conditions of production shall be grouped together to constitute a lot. The conformity of a lot to the requirements of this Employer's Requirements shall be ascertained on the basis of tests on pipes selected from it.

The number of pipes to be selected from the lot for testing shall be in accordance with Table 15 of IS: 458.

Pipes shall be selected at random. In order to ensure randomness, all the pipes in the lot may be arranged in a serial order and starting from any pipe, every pipe be selected till the requisite number is obtained, or being the integral part of N/n where N is the lot size and n is the sample size.

All pipes selected shall be inspected by Engineer for dimensional requirements, finish and deviation from straight. A pipe failing to satisfy one or more of these requirements shall be considered as defective.

The number of pipes to be tested shall be in accordance with column 4 of Table 15 of IS:458. These pipes shall be selected from pipes that have satisfied the requirements mentioned in the above clause.

A lot shall be considered as conforming to the requirements of IS:458 if the following conditions are satisfied.

The number of defective pipes shall not be more than the permissible number given in column 3 of Table 15 of IS: 458.

All the pipes tested for various tests shall satisfy corresponding requirements of the tests.

In case the number of pipes not satisfying requirements of any one or more tests, one or two further samples of same size shall be selected and tested for the test or tests in which the failure has occurred. All these pipes shall satisfy the corresponding requirements of the test.

All result of tested data must be prepared by contractor at site so that the Engineer shall make decision of "fail or pass" at once. All cost for the test shall be borne by the Contractor.

(k) Marking

The following information shall be clearly marked on each pipe:

a) Internal and External diameter and length of pipe
b) Class of pipe
c) Date of manufacture and
d) Name of manufacturer or his registered trade-mark or both.

8.42 Jointing

General

Jointing of RCC pipes shall be done as per the requirements of following Employer's Requirements and as per the relevant IS standard. After jointing, extraneous material, if any, shall be removed from the inside of the pipe and the newly made joints shall be thoroughly cured. In case, rubber sealing rings are used for jointing, these shall conform to IS: 5382. The pipe joint work must be done neatly and keep even slope and level for pipe laying works.

(a) Spigot and Socket joint (Rigid)

The spigot of each pipe shall be slipped home well into the socket of the pipe previously laid and adjusted in the correct position. The opening of the joint shall be filled with stiff mixture of cement mortar which shall be rammed with caulking tool. This joint is used for low pressure pipe line.

(b) Collar Joint (Rigid)

After laying the RCC pipes at proper alignment and gradient their abutting faces shall be coated with hot bitumen in liquid condition by means of a brush. The wedge-shaped groove in the end of the pipe shall then be filled with a tarred gasket in one length for each joint. The collar shall then be slipped over the end of the pipe and the next pipe butted well against the tarred gasket by suitable appliances approved by the Engineer so as to thoroughly compress the tarred gasket into the grooves, care being taken that the concentricity of the pipes and levels are not disturbed during this operation.

The collar shall then be place symmetrically over the end of the two pipes and the space between the inside of the collar and the outside of the pipe filled with a mixture of cement and sand to withstand any stress and prevent any water leakage, tempered with just sufficient water to have a consistency of the semi-dry conditions, well packed and thoroughly rammed with caulking tools. The joints shall be

finished off with a fillet sloping at 45^0 to the side of the pipe. The finished joints shall be protected and cured thoroughly as directed by the Engineer. Any plastic solution or cement mortar that may have been squeezed into the inside of the pipe shall be removed so as to leave the inside of the pipe perfectly clean.

(c) Flush Joint (Internal)

This joint shall be generally used for culvert pipes of 900 mm diameter and over. The ends of the pipes are specially shaped to form a self-centering joint with an internal jointing space 13 mm wide. The finished joint is flush with both inside and outside with the pipe wall. The jointing space is filled with cement mortar mixed sufficiently dry to remain in position when forced with a trowel or rammer.

(d) Flush Joint (External)

This joint is suitable for pipes which are too small for jointing from inside. This joint is composed of specially shaped pipe ends. Each end shall be butted against each other and adjusted in correct position. The jointing space shall then be filled with cement mortar sufficiently dry and finished off flush. Great care shall be taken to ensure that the projecting ends are not damaged as no repairs can be readily affected from inside the pipe.

(e) Spigot and Socket (Semi-flexible)

This joint is composed of specially shaped spigot and socket ends on the RCC pipes. A rubber ring shall be lubricated and then placed on the spigot which is forced into the socket of the pipe previously laid. This compresses the rubber ring as it rolls into the annular space formed between the two surfaces of the spigot and socket, stiff mixture of cement and mortar shall then be filled into the remaining annular space with a caulking tool.

(f) Collar Joint (Semi-Flexible)

This joint is made up of a loose collar which covers two specially shaped pipe ends. Each end shall be fitted with a rubber ring which when compressed between the spigot and collar, seals the joint. Stiff mixture of cement mortar shall then be filled to withstand stress and prevent any water leakage, into the remaining annular space and rammed with a caulking tool.

(g) Spigot and Socket Joint (Flexible)

The RCC pipe with the rubber ring accurately positioned on the spigot shall be pushed well home into the socket of the previously laid pipe by means of uniformly applied pressure with the aid of a jack or similar appliance. The RCC pipes shall be of spigot and socket type and rubber rings shall be used, and the manufacturer's instructions shall be deemed to form a part of these Employer's Requirements. The rubber rings shall be lubricated before making the joint and the lubricant shall be soft soap water or an approved lubricant supplied by the manufacturer.

(h) Cleaning of Pipes

As soon as a stretch of RCC pipes has been laid complete from manhole to manhole or for a stretch as directed by the Engineer, Contractor shall run through the pipes both backwards and forwards a double disc or solid or closed cylinder 75 mm less in diameter than the internal diameter of pipes. The open end of an incomplete stretch of pipe line shall be securely closed as may be directed by the Engineer to prevent entry of mud or silt etc.

If as a result of the removal of any obstructions the Engineer considers that damages may have been caused to the pipe lines, he shall be entitled to order the stretch to be tested immediately. Should such test prove unsatisfactory, contractor shall amend the work and carry out such further tests as are required by the Engineer.

It shall also be ascertained by contractor that each stretch from manhole to manhole or the stretch as directed by Engineer is absolutely clear and without any obstruction by means of visual examination of the interior of the pipe line suitably enlightened by projected sunlight or otherwise.

(i) Testing at work site

After laying and jointing of RCC pipes is completed the pipe line shall be tested at work site as per the following Employer's Requirements and as directed by the Engineer. All equipment for testing at work site shall be supplied and erected by contractor. Water for testing of pipes shall be arranged by him. Damage during testing shall be contractor's responsibility and shall be rectified by him to full satisfaction of the Engineer. Water used for the test shall be removed from pipes and not released to the excavated trenches.

After the joints have thoroughly set and have been checked by the Engineer and before back filling the trenches, the entire section of the sewer or storm water drain shall be proved by the contractor to be water tight by filling in pipes with water to the level of 1.50m above the top of the highest pipe in the stretch and heading the water up for a period of one hour. The apparatus used for the purpose of testing shall be approved by the Engineer. Contractor if required by the Engineer shall dewater the excavated pit and keep it dry during the period of testing. The loss of water over a period of 30 minutes should be measured by adding water from a measuring vessel at regular 10 minutes intervals and noting the quantity required to maintain the original water level. For the approval of this test the average quantity added should not exceed 1 liter/ hour/100 linear metres/10 mm of nominal internal diameter. Any leakage including excessive sweating which causes a drop in the test water level will be visible and the defective part of the work should be removed and made good.

In case of pressure pipeline, the completed stretch of pipeline shall be tested for site test pressure. The site test pressure should not be less than the maximum operating pressure plus the calculated surge pressure, but in no case should it exceed the hydrostatic test pressure as specified in IS: 458.

All of results of test and inspection data must be prepared by contractor at site so that the Engineer shall make decision of "fail or pass" at once. All cost for the inspection shall be borne by the Contractor.

8.43 Steel Cylinder Pipes and Specials

8.43.1 Design

In general the design of steel cylinder pipes with concrete lining and coating shall conform to clause 8 of IS 1916. In addition to above, in case of buried pipe line, the pipe shall also be designed for the Earth load, and traffic load.

8.43.2 Manufacturing

(a) General

Steel cylinder pipes and specials with concrete lining and coating shall be systematically checked for any manufacturing defects by experienced supervisors and a very high standard of quality shall be maintained. The pipes and specials shall be inspected by Engineer at site and factory, and defects noticed, if any, such as protrusions, grooves, dents, notches, etc. shall be rectified, if agreed to by the Engineer. Care shall be taken that the resulting wall thickness does not become less than the minimum specified. If the wall thickness becomes less than the minimum specified, as per Table 1 of IS: 1916, the damaged portion should be cut out as cylinder and replaced by an undamaged piece of pipe at no extra cost to the Engineer.

The Engineer shall at all reasonable times have free access to the place where the pipes and specials are manufactured for the purpose of examining, inspection and testing the pipes and specials and for witnessing the test and manufacturing.

All tests specified either in this Employer's Requirement or in the relevant Indian Standards shall be performed by Supplier/Contractor at his own cost and in presence of the Engineer, if desired. For this sufficient notice before testing of the pipes and specials shall be given to the Engineer.

If the test is found unsatisfactory, the Engineer may reject any or all pipes and specials of that lot. The decision of the Engineer in this matter shall be final and binding on the Contractor.

(b) Materials

All material shall conform to Clause 7 of IS 1916.

(c) Manufacturing Process

Steel cylinder pipes with concrete lining and coating shall be manufactured as per Clause No.9 of IS: 1916 and specials shall be manufactured as per Clause 7 of IS:7322. In case of spiral welded pipes, they

shall be manufactured as per Clause 3 of IS: 5504. Internal lining shall be upto the full length of the pipes and specials. However, external coating shall be done leaving about 100 mm length of the pipes and specials from their ends. The internal lining and external coating to pipes and specials shall be done at factory. Before lining/coating by concrete/mortar the surface of pipes and specials shall be thoroughly cleaned. In the event that loose mill scale, tuberculation, or an accumulation of dirt, debris, oil or grease is present, it shall be removed from the surface by hand, by machine or both and given a coating of neat cement slurry.

(d) Dimensions

The clear cover to the reinforcement whether steel cylinder or cage shall be not less than 9 mm for lining of pipe/special and 12 mm for coating of the pipe/special.

The permissible tolerance for diameter and length of pipe shall be as per Clause 4 of IS: 1916, whereas for diameter, arm length and angular deviation of specials the tolerance limit shall be as per Clause 6 of IS: 7322.

(e) Workmanship and Finish

Workmanship and finish of pipe shall conform to Clause 4 of IS: 1916.

(f) Testing

Each steel cylinder shall be subjected before lining/coating to a hydrostatic test under a water pressure equivalent to the test pressure in accordance with Clause 10 of IS:1916 and relevant provisions of IS:3597, provided that the whole of the area of the calculated reinforcement is used in the steel cylinder. In the case of pipes where a part of the principal reinforcement is provided in the cage, the steel cylinder shall be subjected to proportionately less hydrostatic test pressure.

Manufacturer's standard specials shall be hydrostatically tested before lining/coating. Where feasible, other specials shall be hydrostatically tested (before lining/coating) at factory. However, when this is not practicable, at the discretion of the Engineer, the unlined specials shall be tested by penetration test as per IS: 3658 or other approved means.

All of results of test and inspection data must be prepared by contractor at site so that the Engineer shall make decision of “fail or pass” at once. All cost for the inspection shall be borne by the Contractor

(g) Penetration Test

A suitable liquid penetrant (kerosene oil/Dye) is applied to the surface of the portion under examination and is permitted to remain there for sufficient time to allow the liquid to penetrate into any defects open at the surface. After the penetrate time, the excess penetrant which remains on the surface, is removed. Then a light colored powder absorbent called a developer is applied to the surface. This developer acts as a blotter and draws out a portion of the penetrant which had previously seeped into the surface

openings. As the penetrant is drawn out it diffuses into the coating of the developer, forming indication of the surface discontinuities or flaws.

(h) Marking

The following information shall be clearly marked on each pipe and special:

i) Internal diameter, external diameter and thickness
ii) Class of pipe and special with its serial number
iii) Date of manufacture and
iv) Name of manufacturer or his registered trademark or both

(i) Jointing

Jointing of steel cylinder pipes and specials with concrete lining and coating be done as per the relevant IS. After jointing, extraneous material if any, shall be removed from the inside of the pipe and special. The welding of joints for pipes and specials at work sites shall comply with 816. Electrodes used for welding shall comply with IS: 814.

i. Butt Welded Joint

After pipes and specials are laid in the trench, the faces of pipes/specials shall first be tack-welded alternately at one or more diametrically opposite pairs of points. After completing tack welding, full welding shall be carried out in suitable runs following a sequence of welding portions of segments diametrically opposite. After jointing the exposed surface of the steel cylinder of pipes and specials shall be coated with M20 cement concrete of sufficient thickness so as to make it flush with the adjoining both inner and outer faces of pipes and specials. The gap in the internal lining at the joints shall be filled with cement mortar (1:2) for pipes and specials larger than 600 mm diameter. The lining/coating shall be done after the field test in the section has been successfully completed.

ii. Lap Welded Joint with Slip-in-ends

In the case of pipes with plain or slip-in-ends, swaged end of the steel cylinder may be formed by heating one of its ends and expanding it or rolling it out to the required shape. The minimum depth and maximum clearance between the swaged end and the plain end of pipes for field welding shall be provided as directed by the Engineer. Lap welding shall be done from the external face at the junction of pipe and socket. After jointing the exposed surface of the steel cylinder of pipes and specials shall be coated with M20 cement concrete of sufficient thickness so as to make it flush with the adjoining both inner and outer faces of pipes and specials. The gap in the internal lining at the joints shall be filled with cement mortar (1:2) for pipes and specials larger than 600 mm diameter. The lining/coating shall be done after the field test in the section has been successfully completed.

iii. Flanged Joints

The flanges for steel cylinder pipes and specials shall be as per BS EN 1092-1/BS4504. Flanges shall be provided at the end of pipes or specials where valves, blank flanges etc. have to be introduced or flanged joints for the pipes are specified. The flanges shall have necessary bolt holes drilled. It might be necessary for contractor to follow the instructions and specifications given by the valve manufacturer. All bolts, nuts and packing material required for flanged joints shall be provided by the Contractor. Bolts and nuts shall conform to IS: 1367 whereas rubber gasket of required thickness shall conform to IS: 638.

The bolts shall be evenly tightened in comply with relevant BS standard. Random inspection shall be carried out by jointly the Engineer and the contractor.

(j) Cleaning of pipes and specials

Contractor shall ascertain that each stretch of pipeline is absolutely clear and without any obstruction by means of visual examination of the interior of pipeline suitably lighted by projected sunlight or otherwise. The open end of an incomplete stretch of pipeline shall be securely closed as may be directed by the Engineer to prevent entry of mud or silt etc.

If as a result of the removal of any obstructions the Engineer considers that damages may have been caused to the pipeline, he shall be entitled to order the stretch to be tested immediately. Should such test prove unsatisfactory, contractor shall amend the work and carry out such further tests as are required by the Engineer.

(k) Testing at work site

After laying and jointing of steel cylinder pipes and specials with concrete lining and coating is completed the pipeline shall be tested at work site as per the following Employer's Requirements and as directed by the Engineer. All equipment for testing at work site shall be supplied and erected by Contractor. Water for testing of pipes shall be arranged by him. Damage during testing shall be Contractor's responsibility and shall be rectified by him to the full satisfaction of the Engineer. Water used for test shall be removed from pipes and not released to the excavated trenches.

Each section of the pipe line shall be slowly filled with clean water and all air shall be expelled from the pipeline. The pressure in the pipeline should then be raised and maintained by means of pump to the test pressure. The test pressure should not be less than 1 1/2 times the working pressure at the lowest point or the static head pressure, whichever is higher. Under the test pressure no leak or sweating shall be visible at the welded joints. The duration of test shall be not less than 24 hours. The exposed joints shall be carefully examined and all such joints showing visible leaks shall be rewelded. Any cracked or defective pipes and specials in consequences of this pressure test shall be removed and replaced by sound material by Contractor and the test shall be repeated to the satisfaction of the Engineer.

Proper arrangement of thrust blocks shall be provided during pressure testing or pipe laying works.

8.44 Steel Pipe work

Pipe/fitting material and dimensional standard shall conform to following:

Size mm (NB)	Material Specification (Steel)	Dimensional Standard
Pipes upto 150 mm	1239 PT, ERW, Black PT-1 HVY	1239 ERW
200 to 2400	2062	3589 – ERW 3589 for dimensions and minimum thickness. Pipe thickness shall be as per 2825
Elbows upto 25	ASTM–A 105	ANSI B 16.11 3000 # S.W.
40 to 150	ASTM-A 234 GR WPB	ANSI B 16.9
200 & above (meters)	2062	LR. BE. Sch 40 ANSI B 31.1
Coupling upto 25	ASTM-A 105	ANSI B 16.11 3000 # S.W.
Tees 40 to 200	ASTM – A 234 GR WPB	ANSI B 16.9 BE, Sch 40
Above 200	IS 2062	IS 2825 (min. Pipe thickness)
Reducers upto 25	ASTM-A 105	ANSI B 16.11 3000 S.W.
40 to 200	ASTM-A 234 GR WPB	ANSI B 16.9 BE, Sch 40
Above 200	2062	IS 2825 (min. Thickness for larger pipes)
Flanges	2062	BS EN 1092-1
Bolts, Anchor Bolts and all nuts	SS316	1364
Gaskets All	638 (rubber) reinforced	3 mm thickness

Facilities shall be provided for draining the pipe system and releasing air.

The pipe work layout within pump stations shall have the approval of the pump manufacturer. Fluid velocities in suction pipe work leading to pumps shall not exceed 1.5 m/s. Fluid velocities in delivery pipe work leading from pumps shall not exceed 2.0 m/s.

The whole of the jointing work and materials necessary to fix and connect the pipes, including adequate and efficient pipe support shall be included in the Contract. The Contractor shall be responsible for ensuring that the internal surface of all pipe work is thoroughly cleaned before and during erection and before commissioning.

Cleaning shall include removal of all dirt, rust, scale and welding slag due to Site welding. Before dispatch from the manufacturer's works, the ends of the pipes, branch pipes, etc., shall be suitably capped and covered to prevent any accumulation of dirt or damage. This protection shall not be removed until immediately prior to connecting adjacent pipes, valves or pumps. All small bore pipes shall be blown through with compressed air before connection is made to instruments and other

equipment. No point of passage of pipes through floors or walls shall be used as a point of support, except with the approval of the Employer.

Hydrostatic shop test for pipes and fittings shall be as per code/standard requirement. After erection at site, complete pipes and fittings shall be hydrostatically tested for a pressure of 1.5 times operating pressure.

Flanges, if fabricated in segments shall be fully radiographed and stress relieved. If fabricated out of billets/bars by cold rolling, welded flanges shall be radiographed and normalized.

Protection for pipes laid underground shall be by coating and wrapping system giving a final coat thickness of 4.5 mm may be employed. Such protection shall comprise 1.5 mm of coal tar primer application on a thoroughly cleaned surface, to be followed with fiber glass wraps set in coal tar enamel coats conforming to American Water Works Association Specification C/203/57 for a total thickness of 3 mm. Such lining shall meet a spark test to be approved with a holiday detector of 10000 Volts.

The Contractor shall indicate on his detailed drawings what thrust blocks are required to anchor pipe work supplied by him. Particular care shall be taken to ensure that pipe work thrusts are, as far as possible, not transmitted to machinery or other associated apparatus.

Puddle flanges shall be fitted to pipes where the structure through which they pass is required to take thrust resulting from the pipe. Puddle flanges shall also be fitted where a water barrier is required. All puddle flanges shall be clearly shown on the drawings and the resultant thrust clearly indicated. Puddle flanges shall only be fitted with the prior approval of the Employer.

Buried pipes shall in addition be designed to withstand external loading exerted by soil, water, and live loads as relevant. The external ground water shall be taken at ground level for design purposes. Saddle type/bracket type support wherever required shall be designed and supplied for the above ground pipe lines.

All pipe joints shall be of the butt welded type. End preparations and fabrication requirements shall generally conform to I.S. 2825. Flanges, if fabricated in segments, shall be fully radiographed and stress relieved.
Laying of welded steel pipes shall meet the requirements of I.S. 5822.

(a) Welded Joints for Steel Pipes

Welding of joints in steel pipes shall be carried out manually by the metal arc welding process complying with AWWA Standard C206.

Before starting the welding of pipe joints in the Works the Contractor shall submit for the Engineer's approval details of the plant, methods and materials he proposes to use, including make and size of electrodes, number of runs, current strength and arrangements for air testing of individual joints.

Welding shall only be carried out by welders approved by the Engineer and each welder shall identify his work by means of a stenciled mark.

Welded joints other than for closing lengths shall be of the spherical spigot and socket type. For pipes of 675 mm diameter and smaller the pipe joint shall be welded externally. For pipes larger than 675 mm the pipe shall be welded internally and a sealing weld made externally.

All parts to be welded shall have loose scale, slag, rust, paint and other foreign matter removed by means of a wire brush and shall be left clean and dry. All scale and slag shall be removed from each weld run when it is completed. Pipes manufactured with longitudinal or spiral welds shall be lined up before jointing so that these welds are at least 15^{o} apart around the joint circumference.

For pipes larger than 900 mm diameter a triple run convex fillet weld shall be used. For pipes of 900 mm diameter or less a double run convex fillet weld shall be used. The minimum leg length of the fillet as deposited is to be equal to the full thickness of the pipe wall. The actual throat depth shall not be greater than 9/10th and not less than 7/10th of the minimum leg lengths as deposited. The depositing of the weld metal shall be carried out in such a manner as to ensure that all the welds have adequate root fusion and are of good clean metal free from cracks, gas holes, slag inclusions and all other impurities. The surface of the weld shall have an even contour with regular finish and shall indicate proper fusion with the parent metal. All slag shall be thoroughly removed after depositing each run of welding by light hammering with a chipping hammer followed by wire brushing. Any welds showing cracks or other cavities or in which the weld metal tends to overlap on to the parent metal without proper fusion or containing any other defects whatsoever shall be cut out and rewelded to the satisfaction of the Engineer at the Contractor's expense.

At closing lengths where two plain ended pipes are to be joined by a welded joint the gap between the two ends shall not exceed 75 mm. An external steel sleeve collar, of a thickness not less than that of the pipe itself and approximately 300 mm in length shall be placed centrally over the two ends to be jointed and the end of each pipe shall then be fillet welded to the sleeve collar in accordance with the above procedure.

No weld or adjacent parts of the pipe shall be painted prior to inspection by the Engineer.

(b) Welder Performance Test

The Contractor shall submit for the Engineer's approval the names of persons whom he proposes to employ as welders with evidence that, as a minimum preliminary qualification, they have passed the qualifying tests prescribed in Clause 11 of BS 2633 and possessed certificates from an independent testing authority. The Engineer may further require any such person to perform satisfactory test welds under Site conditions and on pipes similar to those for use in the Works, before approving his employment as a welder. The Contractor shall maintain an up-to-date list of welders approved by the Engineer and if ordered by the Engineer he shall remove from the approved list any welder whose workmanship, as demonstrated by the results of air pressure tests on individual welded joints, is below a reasonable standard of quality of consistency in the Engineer's opinion.

(c) Testing of Welded Joints

Where directed by the Engineer welded joints on pipes larger than 675 mm diameter shall be subject to a nitrogen gas test after welding.

A tapped hole (approximately 6 mm diameter) shall be made in the socket end of each pipe by the Contractor and shall be fitted with a suitable non-return valve. Nitrogen, at 400 kPa pressure, shall then be pumped into the annular space between the spigot and socket and the pump disconnected.

If no drop in pressure occurs over the ensuing period of 30 minutes the test shall be deemed to be successful. If the test pressure cannot be maintained for 30 minutes all defects in the weld shall be cut back and rewelded and the test reapplied until successful. The cost of initial and subsequent testing of defective welds shall be at the Contractor's own expense.

The Contractor shall provide all items necessary for the nitrogen tests including compressor, valves, gauges and tubing.

(d) Hydraulic Losses

The frictional losses due to fluid flow in pipe work shall be computed, based on the Hazen- William formula using C=110

a) Valves

The losses in mwc shall be calculated as per empirical formulas k= coefficient shall be taken as under.

k - For sluice valves	= 0.2
For butterfly valves	= 0.3
For non-return valves	= 1.5
For penstocks	= as furnished by the manufacturer with documentary evidence.

b) Fittings, specials

For specials like reducers, bell-mouths, tees, elbows, etc, the `k' values shall be as recommended by the British Hydromechanics Research Association (BHRA), Volume 5, in the BHRA fluid Engineering Series.

(e) Pipe work Protection

All underground steel piping shall have their external surfaces protected by application of one coal tar enamel coat, wrapping of fiberglass, one more coat of enamel and a final wrap of enamel impregnated fiberglass. Pipe surface shall be thoroughly cleaned by shot or sand blasting. Primer paint recommended by the enamel manufacturer for the grade of enamel used shall be applied over this cleaned surface within four hours of cleaning. The primer paint shall be thoroughly mixed and applied as recommended by the manufacturer and the coating shall be free of bubbles, globules, drips and runs. The primer shall be thoroughly dry before enamel is applied and the latter shall not be applied later than 3 days after application of primer. First flood coat of enamel shall be overlaid by a

single spiral wrap of fiberglass overlapping at least 20 mm on pipe up to 250 mm diameter and 25 mm on larger diameter pipes. Enamel shall be heated slowly in clean kettles, equipped with indicating or recording thermometers (100°C to 350°C range), to the recommended temperature. The enamel shall be stirred continuously. It shall be seen that fiberglass impregnates in the flood coat. Second coat of enamel and second wrap of bitumen impregnated fiberglass shall be applied in the same way. The total thickness of the coating shall not be less than 2.5 mm. Each end of the pipe left bare for a distance of 150 mm for welding shall be hand coated and wrapped after field welding is completed and hydro tested. Testing of pipe protection shall be done as directed by the Engineer using elcometers, coating thickness guages, and bond test and holiday detectors.

(f) External protection

All underground pipework having a cover less than 1.5 m and more than 4.5 m shall be encased with M 15 concrete of minimum 200 mm thick all around.

All underground pipelines having a cover more than 1.5 m shall be externally protected by guiniting of minimum 40 mm thick as per specification.

All above ground and pipes in galleries shall be externally painted with two coats of epoxy with minimum thickness of 180 microns.

(g) Flexibility in Pipe work

The Contractor shall provide flexibility in the pipe work at joints in the main structures and shall submit proposals for the approval of the Engineer. Flexible joints or collars and cut pipes shall be allowed on all pipe work where necessary to allow for some margin of error in the building work. Wherever possible flexible joints shall be provided (as per Engineer's directive) with tie bolts or other means to transfer longitudinal thrusts as a whole so that external anchorages may be kept to a minimum. Flexible joints (SS 304 Bellows and Dismantling joints) shall also be provided for case of erection and future dismantling of all valves and Equipment. Particular care shall be taken to ensure that pipe work thrusts are not transmitted to machinery or associated apparatus.
The Contractor shall indicate on his detailed drawings what thrust blocks are required.

(h) Puddle Flanges

Puddle flanges shall be fitted to pipes where the structure through which they pass is required to take thrust resulting form the pipe. Puddle flanges shall also be fitted where a water barrier is required. All puddle flanges shall be clearly shown on the drawing and the resultant thrust clearly indicated. Puddle flanges shall only be fitted with the Engineer prior approval.

(i) Small Bore Pipes and Hoses

Small bore pipes and hoses shall be of non-flame propagating materials. They shall be arranged for easy dismantling for cleaning where appropriate, and if screwed joint or joints formed by solvent

welding are proposed for any chemical line, a sufficient number of flanged or flexible joints shall be provided to enable the pipe work to be removed in sections without working from one end to the other of a particular run. Tees and cocks shall also be provided at convenient points for the connection of a pressure water supply to flush pipe work through as required.

All pipes and hoses shall be labelled to enable individual lines to be identified throughout their run. Racks or trays shall be fixed to the duct walls or walls of tanks and buildings and the chemical pipes shall be fixed to these racks or trays with clips which can easily be removed without dismantling adjacent pipes. The Contract includes for the supply and fixing of all such racks or trays. Full details of the type of hoses, pipes and racks of trays proposed, shall be submitted at the time of tendering.

(j) Support of Pipe work and Accessories

All necessary supports, saddles, slings, fixing bolts and foundation bolts shall be supplied to support the pipe work and its associated equipment in an approved manner. Valve, meters, strainers, and other devices mounted in the pipe work shall be supported independently of the pipes to which they connect.

All brackets or other forms of supports, which can conveniently be so designed, shall be rigidly built up of steel by riveting or welding in preference to the use of castings.

No point of passage of pipes through floors or walls shall be used as a point of support, except with the approval of the Engineer.

After the collars and boxes or other fitting have been fixed in position, the floors, walls and roof structure will be made good by the Contractor.

8.45 Cast Iron Pipes

8.45.1 Manufacturing

(a) General

C.I. pipes and fittings shall be systematically checked for any manufacturing defects by experienced supervisors and a very high standard of quality shall be maintained.

Engineer shall at all reasonable times have free access to the place where the pipes and fittings are manufactured for the purpose of examining and testing the pipes and fittings and for witnessing the test and manufacturing.

All tests specified either in this Employer's Requirements or in the relevant Indian Standards shall be performed by the supplier/contractor at his own cost and in presence of the Engineer if desired. For this, sufficient notice before testing of the pipes and fittings shall be given to the Engineer.

If the test is found unsatisfactory, the Engineer may reject any or all pipes and fittings of that lot. The decision of the Engineer in this matter shall be final and binding of the Contractor and not subject to any arbitration or appeal.

(b) Materials

The general requirements relating to the supply of material shall be as per IS: 1387.

The material for pipes and fittings shall be of good quality cast iron conforming to IS: 210 (Grade -FG 150).

(c) Dimensions

The internal diameter, thickness and length of barrel, dimensions of pipes and fittings shall be as per the relevant tables of IS: 1536/1537/1538 for different class of pipes and fittings.

The tolerances for pipes and fittings regarding dimensions and deviations from straight line in case of pipes shall be as per relevant IS codes.

The standard weight of uncoated pipes and fittings and the permissible tolerance shall be as per relevant IS codes.

(d) Workmanship and Finish

The pipes and fittings shall be stripped, with all precautions necessary to avoid warping or shrinking defects. The pipes and fittings shall be free from defects, other than any unavoidable surface imperfections which result from the method of manufacture and which do not affect the use of the pipes in the opinion of Engineer.

The pipes and fittings shall be such that they could be cut, drilled or machined and may be accepted provided the hardness of the external unmachined surface does not exceed 230 HBS. In the case of spigot and socket pipes and fittings for lead joints, the socket shall be without the centering ring.

In the case of flanged pipes the flanges shall be at the right angles to the axis of the pipe and machined on face. The bolt holes shall be drilled and located symmetrically off the centre line. The bolt hole circle shall be concentric with the bore and bolt holes equally spaced. The flanges shall be integrally cast with the pipes and fittings and the two flanges of the pipe shall be correctly aligned.

(e) Testing

(i) Mechanical Tests

Mechanical tests shall be carried out during manufacture of pipes and fittings as specified in relevant IS codes. The results so obtained shall be considered to represent all the pipes and fittings of different sizes manufactured during that period and the same shall be submitted to the Engineer. The method for tensile tests and the minimum tensile strength requirement for pipes and fittings shall be as per relevant IS codes.

(ii) Brinell Hardness Test

For checking the Brinell hardness, the test shall be carried out on the test ring or bars cut from the pipes used for the ring test and tensile test in accordance with IS 1500.

(iii) Retests

If any test piece representing a lot fails in the first instance, two additional tests shall be made on test pieces selected from two other pipes from the same lot. If both the test results satisfy the specified requirements, the lot shall be accepted. Should either of these additional test pieces fail to pass the test, the lot shall be liable for rejection.

(iv) Hydrostatic test

For hydrostatic test at works, the pipes and fittings shall be kept under test pressure as specified in relevant IS codes for 15 seconds, they may be struck moderately with a 700 g hammer. They shall withstand the pressure test without showing any leakage, sweating or other defect of any kind. The hydrostatic test shall be conducted before coating the pipes and fittings.

(f) Coating

Coating shall not be applied to any pipe and fitting unless its surface is clean, dry and free from rust. All pipes and fittings shall be coated externally and internally with the same material, by dipping in a tar or suitable base bath. The pipe and fitting may be either preheated before dipping or the bath may be uniformly heated. The coating material shall set rapidly with good adherence and shall not scale off. In all instances where the coating material has a tar or similar base, it shall be smooth and tenacious and hard enough not to flow when exposed to a temperature of 65^{o} C, but not so brittle at a temperature of 0^{0}C as to chip off when scribed lightly with a penknife. In case of pipes and fittings which are imperfectly coated or where the coating does not set or conform to the required quality, the coating shall be removed and the pipes and fittings recoated.

In case the pipes are to be used for conveying potable water, the inside coating shall not contain any constituent soluble in such water or any ingredient which could impart any taste or odour whatsoever to the potable water after disinfection and suitable washing of the mains.

(g) Marking

Each pipe and fitting shall have cast, stamped or indelibly painted on it the following appropriate marks:

i) The nominal diameter.
ii) Flow direction and line marks for installation
iii) Class reference
iv) Mass of pipe
v) Date of manufacture and
vi) Manufacturer's name, initials or identification mark.

Marking shall be done as per relevant IS code.

8.46 Jointing

(a) General

Jointing of CI pipes and fittings shall be done as per the requirements of following Employer's Requirements and as per the relevant IS. After jointing, extraneous material, if any, shall be removed from the inside of the pipe. In case, rubber sealing rings are used for jointing, these shall conform to IS: 5382.

(b) Tyton joints

In jointing cast iron spigot and socket pipes and fittings with tyton flexible joints the contractor shall take into account the manufacture's recommendations as to the methods and equipment to be used in assembling the joints. In particular the contractor shall ensure that the spigot end of the pipe to be jointed is smooth and has been properly chamfered, that the rubber ring as per IS: 5382, is correctly positioned in line, before the joint is made. The rubber rings and any recommended lubricant shall be obtained only through the pipe supplier or as otherwise directed by Engineer.

(c) Flanged Pipes

The gaskets used between flanges of pipes shall be compressed fibre board or natural/synthetic rubber conforming to IS: 638, of thickness between 1.5 to 3 mm. The fibre board shall be impregnated with chemically neutral mineral oil and shall have a smooth and hard surface. Its weight per square metre shall be not less than 112 g/mm thickness.

Each bolt should be tightened a little at a time taking care to tighten diametrically opposite bolts alternately. The practice of fully tightening the bolts one after another is highly undesirable. The bolts shall be of mild steel unless otherwise specified.

(d) Cleaning of Pipes and Fittings

The Contractor shall ascertain that each stretch of pipeline is absolutely clear and without any obstruction by means of visual examination of the interior of pipeline suitably lighted by projected sunlight or otherwise. The open end of an incomplete stretch of pipeline shall be securely closed as may be directed by the Engineer to prevent entry of mud or silt etc.

If as a result of the removal of any obstructions the Engineer considers that damages may have been caused to the pipeline, he shall be entitled to order the stretch to be tested immediately. Should such test prove unsatisfactory, contractor shall amend the work and carry out such further tests as are required by the Engineer.

(e) Testing at work site

After the pipes and fittings are laid, jointed and the trench partially backfilled except at the joints the stretch of pipe line as directed by Engineer shall be subjected to pressure test and leakage test. Where any section of the pipeline is provided with concrete thrust blocks or anchorages, the pressure test shall not be made until at least five days have elapsed after the concrete was cast. If rapid hardening cement has been used in these blocks or anchorages, the tests shall not be made until atleast two days have elapsed.

Each section of the pipe line shall be slowly filled with water and all air shall be expelled from the pipe by tapping at points of highest elevation before the test is made and plugs inserted after the tests have been completed. The specified test pressure based on the elevation of the lowest point of the line or section under test and corrected to the elevation of the test gauge, shall be applied by means of a pump connected to the pipe as directed by the Engineer.

The duration of test shall not be less than 5 minutes. The exposed joints shall be carefully examined and all such joints showing visible leaks shall be recaulked until water tight. Any cracked or defective pipes and fittings in consequence of this pressure test shall be removed and replaced by sound material by Contractor at no extra cost to the Engineer and the test shall be repeated to the satisfaction of the Engineer.

After the satisfactory completion of pressure test, the section of pipe line shall be subjected to leakage test. The duration of test shall be 2 hours. No pipe installation shall be accepted until the leakage is less than the number of cm3 /h as determined by the formula:

$$q_L = \frac{ND\sqrt{P}}{3.3}$$

Where,

q_L = The allowable leakage in cm^3/hr

N = Number of joints in the length of the pipeline

D = Diameter in mm, and

P = The average test pressure during the leakage test in Kg/cm^2

Should any test of pipe laid indicate leakage greater than that specified above, the defective joints shall be repaired by Contractor at no extra cost to the Engineer until the leakage is within the specified allowance.

Necessary equipment and water used for testing shall be arranged by Contractor at his own cost. Damage during testing shall be Contractor's responsibility and shall be rectified by him at no extra cost to the Engineer. Water used for testing shall be removed from the pipe and not released in the excavated trenches.

After the tests mentioned above are completed to the satisfaction of the Engineer, the backfilling of trenches shall be done as per the Employer’s Requirements specified elsewhere.

8.47 Un plasticised PVC Pipes and Fittings

Unplasticised polyvinyl chloride pipes, fittings and specials shall be to BS 3505 for potable water and BS 4346: Part 1 for fittings.

The pipes shall be of the spigot and socket type with approved gasket type flexible joint. The rubber gaskets shall be to BS 2494, Class C.

Where PVC pipes, fittings and specials are to be connected to cast iron, stainless steel or steel pipes, all metallic pipes, 'Viking Johnson' type flange adaptors or stepped couplings shall be used.

(a) Polyethylene Pipes

Polyethylene pipes shall comply with BS 6437. The welding method shall be adapted to international standard and contractor shall obtain the approval of the Engineer before proceeding with such works.

(b) Rubber Hosing

Rubber hosing shall conform to BS 5119, Type 2. It shall be capable of handling chlorine and sulphur dioxide solutions at a working pressure of 12 bar.

(c) Copper Tubes and Fittings

Copper tubing and fittings for work above ground level shall comply with BS 2871 and BS 864: Part 2 respectively and be jointed with capillary joints. For underground location the copper pipe shall be to BS 2871: Part 1.

(d) Flanged Joints

All flanges shall comply with BS EN 1092-1/BS 4504. The nominal pressure rating for particular flanges shall be at least equal to the highest pressure rating of the pipes or fittings to which they are attached, but with a minimum nominal pressure of PN 10. All flanges shall be provided with all necessary nuts, bolts, washers and gaskets. In general, valves shall have flanged body ends.

All flanged joints which are buried or in chambers shall be protected with Densomastic and Densotape wrapping, applied in accordance with the manufacturer's instructions.

Flanges shall be installed on the pipes in the factory and field welding of flanges shall only be allowed with the approval of the Engineer.

Where pipework outside pumping stations and surge vessel chambers is catholically protected, an insulated flange shall be incorporated at the first flange inside the structure. These flanges shall be tested to ensure that electrical insulation is achieved.

(e) Gaskets and Joint Rings

Joint rings shall be manufactured to conform with BS 2494 and shall be of chloroprene rubber or other approved synthetic material suitable for temperatures up to 80^{o}C.

Gaskets may be inside the bolt circle type and shall comply with BS 4865: Part 1. Alternatively the gasket shall be to the full diameter of the flange, drilled to suit the appropriate bolt provisions.

Chloroprene rubber with a hardness of 71 to 80 IRHD shall be used.

Joints shall be made in accordance with manufacturer's instructions or as specified herein.

Until immediately required for incorporation in a joint, each rubber ring or gasket shall be stored in the dark, free from the deleterious effects of heat or cold, and kept flat so as to prevent any part of the rubber being in tension.

Only lubricants recommended by the manufacturer shall be used in connection with rubber rings and these lubricants shall not contain any soluble constituent, shall be suitable for the climatic conditions at the Site and shall contain an approved bactericide.

After cleaning the flanges the gaskets shall be fitted smoothly to the flange and the joint shall be made by tightening the nuts to finger pressure first. Thereafter the final tightening of the nuts shall be made by gradually and evenly tightening bolts in diametrically opposite positions using standard spanners.

Graphite grease shall be applied to the threads of bolts before joints are made.

(f) Flexible Couplings and Flange Adaptors

Flexible couplings and flange adaptors shall be of the Viking Johnson or similar approved pattern and be assembled in accordance with the manufacturer's instructions and protected, if buried or in chambers with Densomastic and Densotape wrapping applied in accordance with the manufacturers' instructions. Flexible joints shall be harnessed or tied where necessary

8.48 Storage & Shipment

(a) Protection of Pipes and Fittings for Shipment

Except where otherwise specified all items shall have received their complete protective coatings before dispatch from the manufacturer's works and shall be additionally protected by approved means for the period of transit, storage and erection, against corrosion and accidental damage.

For the protection of pipe linings and in particular for protecting cement mortar linings from drying out, protective metal or timber discs shall be fitted over the ends of pipes and fittings. Similar timber protective discs shall be attached to all flanges of pipes and fittings, by means of bolts specifically

provided for the purpose and which shall be discarded when the item is incorporated in the Works. The sleeves and flanges of flexible joints shall be wired together in suitable bundles.

(b) Storage of Pipeline Materials

Pipes and fittings shall be stored raised off the ground, and shall be carefully supported, cushioned and wedged. Pipes shall not rest directly on one another and shall not be stacked more than four pipes high or two pipes high in the case of pipes of 500 mm diameter or over. Special care shall be taken to ensure that flexible pipes are cradled and supported in a manner that prevents any distortion of the pipes.

Couplings and joints (and all components thereof) and other similar items shall be stored in dry conditions, raised from the ground in sheds or covered areas.

Storage areas shall be carefully set out to facilitate unloading, and checking of materials with different consignments stacked or stored separately with identification marks clearly visible.

Where items to be stored have a limited shelf life or require special storage arrangements, the method of storage shall be to the approval of the Engineer and in accordance with the manufacturer's instructions.

All pipes and fittings supplied as spares shall have end covers which are proof against the entry of sand and vermin. Mortar lined pipes and fittings shall have end covers which form a complete seal, provision being made to accommodate the effects of temperature changes. Pipes and fittings supplied as spares shall have a temporary white external finish and shall be stored sheltered from the direct rays of the sun.

End covers and protection shall not be removed until incorporation of the pipes and fittings into the Works.

8.49 Transportation of Pipes and Fittings

Any vehicle on which pipes are transported shall have a body of such length that the pipes do not overhang. Large pipes shall be placed on cradles and the loads properly secured during transit. The pipes shall be handled in accordance with the manufacturer's recommendations.

Approved slings shall be used and all hooks and dogs and other metal devices shall be well padded. Hooks engaged on the inner wall surface at pipe ends shall not be used. Steadying ropes shall be employed. The positions of lifting slings shall ensure that stresses and tendency towards deformation in the pipes are kept at a minimum.

Pipe handling equipment shall be maintained in good repair and any equipment which in the opinion of the Engineer may cause damage to the pipes shall be discarded.

Under no circumstances shall pipes be dropped, be allowed to strike one other, be rolled freely or dragged along the ground.

8.50 Inspection of Pipes and Fittings

Before incorporating into the Works each pipe shall be brushed out and carefully examined for soundness. Damaged pipes which in the opinion of the Engineer cannot be satisfactorily repaired shall be rejected and removed from Site.

Damage to pipe coatings or linings shall be repaired to the satisfaction of the Engineer.

Built-in Pipe work and other Plant

The pipes and other Plant in water retaining structures shall, wherever possible, be built in as the work on the structure proceeds. The Contractor shall ensure that delivery of the requisite pipe work and other Plant is in accordance with the requirements of the programme.

Where a pipe subject to thrust passes through a concrete structure or where an external seal is required, a puddle flange shall be used. The puddle flange dimensions shall be to BS EN 1092-1/BS 4504 but shall be undrilled. The exterior of the pipe shall be cement washed symmetrically about the puddle flange by the manufacturer for a length at least equivalent to the thickness of the wall through which it passes.

The Contractor shall be responsible through every stage of the Works for checking the correctness of the setting of built-in Plant and shall satisfy himself they are positioned in accordance with his approved drawings.

8.51 Pipe laying

(A) Carting & Handling

Pipes and fittings /specials shall be transported from the factory to the work sites at places along the alignment of pipeline as directed by the Engineer. Contractor shall be responsible for the safety of pipes and fittings/specials in transit, loading/unloading. Every care shall be exercised in handling pipes and fittings/specials to avoid damage. While unloading, the pipes and fittings/specials shall not be thrown down from the truck on to hard surfaces. They should be unloaded on timber skids with steadying ropes or by any other approved means. Padding shall be provided between coated pipes, fittings/specials and timber skids to avoid damage to the coating. Suitable gaps between pipes should be left at intervals in order to permit access from one side to other. In case of spigot socket pipes, care should be taken regarding orientation of pipes while unloading. As far as possible pipes shall be unloaded on one side of the trench only. The pipes shall be checked for any visible damage (such as broken edges, cracking or spalling of pipe) while unloading and shall be sorted out for reclamation. Any pipe which shows sufficient damage to preclude it from being used shall be discarded. Dragging of pipes and fittings/specials along concrete and similar pavement with hard surfaces shall be prohibited.

(B) Storage

Each stack of pipes shall contain only pipes of same class and size, with consignment or batch number marked on it with particulars of suppliers wherever possible. Storage shall be done on firm level and clean ground and wedges shall be provided at the bottom layer to keep the stack stable. The stack shall be in pyramid shape or the pipes laid lengthwise and crosswise in alternate layers. The pyramid stack shall be made for smaller diameter pipes for conserving space in storing them. The height of the stock shall not exceed 1.5 m.

Fittings/Specials shall be stacked under cover and separated from pipes.

Rubber rings shall be stored in a clean, cool store away from windows, boiler, electrical equipment and petrol, oils or other chemicals. Particularly in the field where the rubber rings are being used it is desirable that they are not left out on the ground in the sun or overnight under heavy frost or snow conditions.

8.52 Laying

(A) Excavation

Before excavating the trench, the alignment of pipeline shall be approved by the Engineer. The excavation of trenches and pits for manholes/ chambers shall be carried out in accordance with the Employer's Requirements described elsewhere and shall be done such that it does not get far ahead of the laying operation as approved by the Engineer.

To protect persons from injury and to avoid damage to property, adequate barricades, construction signs, red lanterns and guards as required shall be placed and maintained during the progress of the construction work and until it is safe for the traffic to use the roadways. The relevant Indian Standards and the rules and regulations of local authorities in regards to safety provisions shall be observed.

Suitable fencing shall be provided along the sides of trenches and pits. The posts of fencing shall be of timber securely fixed in the ground not more than 3 m apart and they shall not be less than 75 mm in diameter or less than 1.2m above surface of the ground. There shall be two rails, one near the top of the post and the other about 450mm above the ground and each shall be from 50mm to 70mm in diameter and sufficiently long to run from post to post to which they shall be bound with strong rope. The method of projecting rails beyond the post and tying them together where they meet will not be allowed on any account. All along the edges of the excavation trenches a bank of earth about 1.2 m high shall be formed where required by the Engineer for further protection.

The road metal and also the rubble packing shall first be stripped off for the whole width of the trench/pit and separately deposited in such place or places as may be determined by the Engineer.

During excavation, large stones and rubble shall be separated and removed from the excavated soil and stacked separately. The material from excavation shall be deposited on either side of the trench leaving adequate clear distance from the edges of the trench and pit, or as may be necessary to prevent the sides of the trench pit to slip or fall, or at such a distance and in such a manner as to avoid covering fire hydrants, sluice valves, manholes and covers etc. and so as to avoid abutting the wall or structure or

causing inconvenience to the public and other service organizations or otherwise as the Engineer may direct.

Contractor shall take into account additional excavation if any as the Engineer may require in order locating the position of water pipes, drains, sewers etc. or any other works which may be met with, in or about the excavation of trenches/pits while quoting the rates for excavation of trenches /pits while quoting the rates of excavation. Such service lines if met with during excavation shall be properly maintained by Contractor, by means of shoring, strutting, planking over, padding or otherwise as the Engineer may direct, and shall be protected by the Contractor from damage during the progress of the work. All precautions shall be taken during excavation and laying operations to guard against possible damage to any existing structure /pipe line of water, gas, sewage etc.

Utmost care shall be taken to see that the width of the trench at the top of pipe is not more than the minimum requirement. In case additional width is required it shall be provided only in the top portion from the ground level upto 300 mm above the top of pipe. If any extra width is provided in the area below this portion, Contractor shall have to provide remedial measures in the form of lime concrete or rubble masonry otherwise at the discretion and to the satisfaction of the Engineer. If rock is met with, it shall be removed to 15 cm below the bottom of pipes and fittings/specials and the space resulting shall be refilled with granular materials and properly consolidated. Bottom of trenches/pits shall be saturated with water well rammed wherever the Engineer may consider it necessary to do so.

Wherever a socket or collar of pipe or fitting/ special occurs, a grip is to be cut in the bottom of the trench or concrete bed to a depth of at least 75 mm below the bed of the pipe so that the pipe may have a fair bearing on its shaft and does not rest upon its socket. Such grip shall be of sufficient size in every respect to admit the hand all around the socket in order to make the joint and the grip shall be maintained clear until the joint has been approved by the Engineer.

When welding is to be carried out with the pipes and specials in the trench, additional excavation of not more than 60cm in depth and 90 cm in length shall be made at joints in order to facilitate welding.

The excess excavated material shall be carried away from site of works to a place up to a distance as directed by the Engineer. This shall be done immediately so as not to cause any inconvenience to the public or traffic. If the instructions from Engineer are not implemented within seven days from the date of instructions to cart the materials and to clear the site, the same shall be carried out by the Engineer and any claim or dispute shall not be entertained in this respect.

(B) Dewatering

During the excavation, if subsoil water is met with Contractor shall provide necessary equipment and labourers for dewatering the trenches. The Contractor shall also make necessary arrangement for the disposal of drained water to nearby storm water drain or in a pit if allowed by the Engineer. In no case the water shall be allowed to spread over the adjoining area. Before discharging this water into public sewer/drain, the Contractor shall take necessary permission from the local authorities.

(C) Special Foundation in Poor Soil

Where the bottom of the trench and sub grade is found to consist of material which is unstable to such a degree that in the opinion of the Engineer, it cannot be removed and replaced with an approved material thoroughly compacted in place to support the pipe properly, a suitable foundation for the pipes, consisting of piling, timbers or other materials, in accordance with relevant drawings to be prepared by the Contractor and as instructed by the Engineer shall be constructed.

(D) Wooden Shoring

Contractor shall suitably design polling boards, waling and struts to meet different soil conditions that might be encountered in excavating trenches/pits. The horizontal and vertical spacing of struts shall be such that not only the sides of trenches shall be prevented from collapse but also easy lowering of pipe in trenches shall be ensured without creating undue obstructions for the excavation of the work. Any inconvenience and/or delay that might be caused in lowering pipes in trenches as a result of adopting improper spacing of struts by Contractor shall be his sole responsibility. No part of shoring shall at any time be removed by Contractor without obtaining permission from the Engineer. While taking out shoring planks the hollows of any form must simultaneously be filled in with soft earth well rammed with rammers and with water.

The Engineer may order portions of shoring to be left in the trenches /pits at such places, where it is found absolutely necessary to do so to avoid any damage which may be caused to buildings, cables, gas mains, water mains, sewers etc. in close proximity of the excavation, by pulling out the shoring from the excavations. The Contractor shall not claim, on any reason whatsoever, for the shoring which may have been left in by him at his own discretion.

(E) Steel Plate Shoring

Where the subsoil conditions are expected to be of a soft and unstable character in trench/pit excavation, the normal method of timbering may prove insufficient to avoid subsidence of the adjoining road surfaces and other services. In such circumstances, the Contractor will be required to use steel trench sheeting or sheet piling adequately supported by timber struts, waling etc., as per the instructions, manner and method directed by the Engineer. Contractor shall supply pitch, drive and subsequently remove trench sheeting or piling in accordance with other items of the Employer's Requirements.

(F) Boning Staves and Sight Rails

In laying the pipes and fittings/ specials the centre for each manhole / chamber or pipeline shall be marked by a peg. Contractor shall dig holes for and set up two posts (about 100 x 100 x 1800 mm) at each manhole/chamber or junction of pipelines at nearly equal distance from the peg and at sufficient distances there from to be well clear of all intended excavation, so arranged that a sight rail when fixed at a certain level against the post shall cross the centre line of the manhole/chamber or pipe lines. The sight rail shall not in any case be more than 30 m apart; intermediate rails shall be put up if directed by the Engineer.

Boning staves of 75 mm x 50 mm size shall be prepared by Contractor in various lengths, each length being of a certain whole number of meters and with a fixed tee head and fixed intermediate cross pieces, each about 300 mm long. The top-edge of the cross piece must be fixed below the top-edge of the tee-

head at a distance equal to the outside diameter of the pipe or the thickness of the concrete bed to be laid as the case may be. The top of cross pieces shall indicate different levels such as excavation for pipe line, top of concrete bed, top of the pipe etc. as the case may be.

The sight rail of size 250 mm x 40 mm shall be screwed with the top edge resting against the level marks. The center line of the pipe shall be marked on the rail and this mark shall denote also the meeting point of the center lines of any converging pipes. A line drawn from the top edge of one rail to the top edge of the next rail shall be vertically parallel with the bed of the pipe, and the depth of the bed of pipe at any intermediate point may be determined by letting down the selected boning staff until the tee head comes in the line of sight from rail to rail.

The post and rails shall be perfectly square and planed smooth on all sides and edges. The rails shall be painted white on both sides, and the tee-heads and cross-piece of the boning staves shall be painted black.

For the pipes converging to a manhole/chamber at various levels, there shall be a rail fixed for every different level. When a rail comes within 0.60 M of the surface of the ground, a higher sight-rail shall be fixed for use with the rail over the next point.

The posts and rails shall in no case be removed until the trench is excavated, the pipes are laid and the Engineer gives permission to proceed with the backfilling.

(G) Laying of Pipes and Fittings/Specials

All precautions shall be taken during excavation and laying operations to guard against possible damage to any existing structure/pipeline of water, gas, sewage etc. After excavation of trenches, pipes shall not be lowered unless the dimensions of trenches and bedding work for pipes at the bottom of the trenches are approved and measured by Employer /Engineer. Pipes and fittings/specials shall be carefully lowered in the trenches. Special arrangements such as cranes, tripods with chain pulley block for lowering the pipes and fittings/specials shall be made by Contractor. In no case pipes and fittings/specials shall be dropped. Slings of canvas or equally non-abrasive material of suitable width or special attachment to fit the ends of pipes and fittings/specials shall be used to lift and lower the coated pipes and fittings/specials. The pipes and fittings /specials shall be inspected for defects and be rung with a light hammer preferably while suspended to detect cracks. If doubt persists, further confirmation shall be done by pouring a little kerosene/dye on the inside of the pipe at the suspected spot. No sign of kerosene/dye should appear on the outside surface. Pipes and fittings/specials damaged during lowering or aligning shall be rejected by the Engineer.

All the pipes are to be laid perfectly true both in alignment and to gradient specified. In case of spigot and socket pipe the socket end of the pipe shall face upstream, except when the pipeline runs uphill in which case the socket ends should face the upgrade. The laying of pipes shall always proceed upgrade of a slope. After placing a pipe in the trench, the spigot end shall be centered in the socket and the pipe forced home and aligned to required gradient. The pipes shall be secured in place with approved backfill material tamped under it except at the socket. Pipes and fittings/specials which do not allow a sufficient and uniform space for joints shall be removed and replaced with pipes and fittings/specials of proper

dimensions to ensure such uniform space. Precautions shall be taken to prevent dirt from entering the jointing space. At times when pipe laying is not in progress, the open ends of pipe shall be closed by a watertight plug or other means approved by the Engineer. During the period that the plug is on, the Contractor shall take proper precautions against floating of the pipe owing to entry of water into the trench. Wherever it is necessary to deflect pipe from a straight line, either in the vertical or horizontal plane, to avoid obstructions or where long radius curves are permitted the deflection allowed at joints shall not exceed 2 ½0. In case of pipes, with joint to be made with loose collars, the collars shall be slipped on before the next pipe is laid. The pipes shall be laid such that the marking on pipes appears at the top of the pipes.

The cutting of pipe for inserting valves, fittings, or specials shall be done in a neat and workman like manner without damage to the pipe so as to leave a smooth end at right angles to the axis of the pipe. For this purpose, pipe cutting machine shall be used.

(H) Thrust Blocks

Thrust Blocks shall be provided for all piping works, to counteract hydraulic thrust, at places wherever directed by the Engineer as per approved design.

(I) Jointing

Jointing for pipes and fittings/specials shall be done in accordance with the relevant Employer's Requirements depending upon the type of pipes being used.

(J) Testing and Commissioning

Testing and commissioning of pipes shall be done in accordance with the relevant Employer's Requirements.

(K) Backfilling

Trenches shall be backfilled with approved selected excavated material only after the successful testing of the pipeline. The tamping around the pipe shall be done by hand or other hand-operated mechanical means. The water content of the soil shall be as near the optimum moisture content as possible. Filling of the trench shall be carried out simultaneously on both sides of the pipe in such a manner that unequal pressure does not occur. Backfilling shall be done in layers not exceeding 30 cm. Each layer shall be consolidated by watering, ramming, care bring taken to avoid damage to the pipeline. In case of the mild steel pipes/specials, the spiders provided during assembly and welding shall be retained until the trench is refilled and consolidated. Where timbers are placed under the pipeline to aid alignment, these timbers shall be removed before backfilling.

The Contractor is requested to provide the method of Backfilling compaction test and evaluation value and obtain the approval from the Engineer.

(L) Reinstatement of Road/Footpath

Reinstatement of road/footpath shall be done as per the requirements of local authorities and the Employer's Requirements after completion of work.

(M) Clearing of Site

All surplus materials, and all tools and temporary structures shall be removed from the site as directed by the Engineer and the construction site left clean to the satisfaction of the Engineer.

End of Part 8

PART 9

GENERAL PAINTING AND PROTECTION REQUIREMENTS

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PART 9

GENERAL PAINTING AND PROTECTION REQUIREMENTS

9.1 General

The preparation, application and conditions for work shall comply with the recommendations of BS 5493 and BS 6150 or if the protection is of a special nature, in accordance with the manufacturer's directions.

Paints, primers and undercoats shall be obtained from the same manufacturer and except where a definite time is specified between mixing and application, shall be ready mixed for use. They shall be compatible with one another.

Paints shall be delivered in sealed containers bearing the manufacturer's name, batch number, etc. and shall carry a label giving details of quality and instructions for use.

No site painting shall be carried out unless the surface to be painted is dry, the air temperature above 4^{o}C and the relative humidity less than 85%. The Engineer shall approve the methods for removing all dirt, oil, grease, etc, before Site painting commences.

The Engineer may require test plates carrying finishes from the actual coating used for inspection and test purposes.

To facilitate inspection, no consecutive coats of paint shall be of the same shade except in the case of white.

Priming to two mating surfaces shall be applied prior to assembly.

All items of Plant shall be delivered to Site with the shop paint finish applied unless specified otherwise. A further coat of final finish paint shall be applied at Site, of sufficient thickness to produce a uniform colour and appearance. Such painting shall be carried out within one month of successful acceptance trials for the Plant.

All paint thicknesses shall be checked using an alkometer or equivalent instrument, supplied by the Contractor, for each layer of paint, to the reasonable satisfaction of the Engineer.

9.2 Colour Coding and Labelling of Pipes and Equipment

All pipes and equipment shall be colour coded to a schedule to be agreed with the Engineer before any site painting starts, or earlier if necessary to suit manufacturing procedures. Valves and fittings shall be painted in the same colour as the pipe of which they form a part. Where a pipe enters or leaves a piece of equipment the pipe colour shall extend up to but not including the flange attached to the equipment.
All pipelines shall be identified by stick-on 90 micron thick vinyl film labels showing the name of the material to be carried by the pipeline and an arrow indicating the direction of flow. Letters of titles shall be pre-spaced on carrier tape and the complete title protected by one piece removable liners. Titles shall be at intervals not less than 8 m, but shall in any case be provided in every space through which the pipe passes. Locations of labels shall be subject to prior approval by the Engineer. Lettering sizes shall be between 16 mm and 75 mm in height depending on the size of the pipe.

Pipes smaller than 22 mm outside diameter shall be labelled by the use of tags instead of labels. Tags shall be made of brass no smaller than 65 mm x 16 mm by 1.5 mm thick, with lettering etched and filled with black enamel.

Titles shall also be provided on all equipment in locations and in sizes to be approved by the Engineer.

9.3 Cleaning and Preparing at Place of Manufacture

The Contractor shall be responsible for the cleaning and preparation for painting, priming or other wise protecting as specified of all parts of the Plant at the place of manufacture prior to packing.

(a) Cleaning

Parts shall be cleaned prior to testing at the manufacturer's works. Parts subject to hydraulic test shall be tested before any surface treatment. After test all surfaces shall be thoroughly cleaned and dried out if necessary, by washing with an approved dewatering fluid prior to surface treatment.

(b) Preparation

Bright parts: Bright parts and bearing surfaces shall be thoroughly polished and protected from corrosion by the application of rust preventive lacquer or high melting-point grease, as approved by the Engineer, before the parts are packed. A sufficient quantity of the correct solvent for removal of the protective compounds shall be supplied and packed with each particular part.

Embedded parts: Embedded parts or those parts of an assembly which will be embedded in concrete shall be thoroughly descaled and cleaned to the satisfaction of the Engineer and before being packed shall be protected by a cement wash or other approved method. No cast iron or steel work shall be bitumen or tar coated where it is to be cast into the concrete and provision shall be made for cleaning off any portions so coated.

Grit or shot blasted parts: Grit or shot blasting shall be carried out in accordance with B.S. 7079 to a standard between `First Quality' and `Second Quality' given in Table 1 after which the maximum amplitude of the surface shall not exceed 0.1 mm.

Cast Iron and Steel pipework: All ungalvanised steel pipework including pump suspension mains, bearing spiders and tunnel tubes shall be prepared internally and externally by grit or shot blasting as specified above and the surfaces primed as specified within four hours of blasting.

9.4 Painting and Finishing at Place of Manufacture

This Clause governs the methods for the protective coatings to be applied to structural steel, metalwork and ironwork as corrosion protection systems. The systems designed as specified here shall be applied as specified under Protective Coatings. Protective coating specified elsewhere for particular works such as pipes and cladding shall firstly be designed in accordance with particular requirements specified elsewhere and secondly in accordance with any requirements herein which are not overridden elsewhere. This specification makes reference to the following standard.

B.S. 5493 "code of practice for the protective coating of iron and steel against corrosion"

The Contractor shall design each protective coating system and shall submit details of each system to the Engineer for approval. Submissions shall where possible be in the format of which examples are given at the end of this section with such additional information and samples as the Contractor may provide or the Engineer may require to enable the system to be assessed.

Protective coating shall be designed in accordance with B.S. 5493 or equivalent to have a long life, generally of at least 10 years to first maintenance. Protection systems shall be chosen to be easily maintained in the future and to allow non-specialist on-site re-coating where necessary using single part paints.

For the purposes of system design the general environment shall be as specified in B.S. 5493 Table 3 Part 2 `Exterior exposed polluted inland'. Bulkhead gates and stoplogs shall be assumed to be exposed to a Table 3 Part 8 `Non-saline water' environment unless otherwise approved by the Engineer.

Interior spaces shall be considered to be dry in administration areas open to continuous access and damp or immersed in other spaces. The protective coating of components or structures which are continuously or infrequently immersed shall be designed for the more onerous of these two conditions relevant to the protection system used.

All exterior exposed items to be coated shall have a final coat of good appearance of a colour and type as approved by the Engineer.

Protective coating systems shall generally fall into one of the following basic systems;

- galvanising;
- galvanising plus painting;
- multi-coat painting;
- Bitumen enamel;
- Others as proposed by the Contractor and approved by the Engineer.

The Contractor shall submit to the Engineer details of his proposals for the corrosion protection of each of the items requiring such protection, which will generally fall into the above categories as follows:

- trash screens, flooring, ladders, access covers and frames, step irons and other components which are inaccessible but subject to abrasion/damage;
- structural steelwork (including crane beams, monorails, crane structures and chassis), bulkhead gates, stoplogs, grappling beams, steel tanks and other large items readily accessible for maintenance;
- valves and other corrosion-susceptible items which may be buried and are not covered by the provisions of other specifications :
- other components not covered by the above for which the contractor may propose a system which he considers to be more suitable for the duty;
- Electrical switchgear, transformers, control panels etc.

All painting material shall be applied in strict accordance with the paint manufacturer's instructions.

(a) Plant supplied to site with final coating applied:

Cubicles, cabinets etc. other than those specified in Part 10.

Before any steel work is painted the steel must be thoroughly cleaned and an approved anti-rusting priming coat applied so that the possibility of rusting or corrosion taking place is negligible. All surfaces should have not less than two stoved undercoats and two top coats or air drying paint. The undercoats shall be easily distinguishable in shade or colour from the priming and finishing coats. The two final coats shall be in a colour and finish to be advised by the Engineer. The inside surfaces of any cubicles, cabinets etc. where condensation is liable to occur, shall be coated with an approved anti-condensation composition. The Contractor shall ensure that all component sections of a switch board wherever manufactured shall have a finish of uniform texture and an exact colour match.

Chromium plated parts: Where chromium plating is specified or offered by the manufacturer it shall comply with the requirements of BS EN ISO 1456 including the following provisions. No blistering of any surfaces will be tolerated. The finished appearance shall be brought. Where the base metal is steel, plating shall be applied in accordance with Table 2. Other base metals shall be plated in accordance with Tables 3, 4, 5 as appropriate. For all base metals the service condition number 2 shall be used.

Small bore pipes, valves and fittings etc., which are sited in architecturally finished areas of the station and selected by the Engineer shall be chromium plated. Damage to chromium plating shall be made good before taking over.

Galvanised parts: All materials to be galvanised shall be of the full dimensions shown on the approved drawings or specified and all punching, cutting, drilling, screw tapping and the removal of burrs shall be completed before the galvanising process begins. Parts to be galvanised shall be shot blasted as specified above. Such parts shall be galvanised not more than four hours after commencement of shot blasting.

All galvanising shall be done by the hot dip-process. No alternative process may be used without the approval of the Engineer. No components shall be galvanised which are likely to come into subsequent contact with oil.

The zinc coating shall be uniform, clean smooth and as free from spangle as possible. In the case of component parts the zinc coating shall weigh not less that 610 g/sq.m of area covered and shall not be less than 0.090 mm in thickness.

Bolts and nuts shall be sherardised. The Engineer may select for test as many components to be weighed after pickling, and before and after galvanizing as he may think fit.

All galvanised parts shall be protected from injury to the zinc coating due to differential serration and abrasion during the periods of transit, storage and erection. Damaged areas of the coating shall be touched up with an approved zinc-dust paint or other approved flake metallic compound.

Cast iron and steel pipework: (Internal surfaces)

The internal surfaces shall have an approved coating.

Where a bitumen based coating is used, it shall be in accordance with Type 2 of BS EN 10300.

Prior to lining, the pipe shall be grit blasted and primed with an approved primer. The lining shall be in accordance with BS EN 10311 & BS EN 10224. After installation, the internal lining shall be made good and satisfactorily tested with a Holiday detector to 8 KV.

The coating shall be suitable for use in contact with drinking water. The type of coating shall be entered in Schedule L provided and the Engineer reserves the right to call for test plates of the paint. The manufacturer shall at the time of ordering carry out the `Taste and smell test' (Appendix E of BS EN 10300) and `Effects on water test' (Appendix C of B.S. 3416) and forward 3 copies of the test results to the Engineer for approval.

Where pipes are to be welded after the protective coatings have been applied, the pipe surfaces shall be primed and all other coatings stopped 250 mm short of the weld preparation. Collars and fillings shall be primed but no other coating applied.

The manufacturer shall supply a sufficient quantity of suitable materials to repair damage occurring during delivery to site and to provided a flush finished internal lining at welded joints. He shall supply sufficient coating to fill in the recesses at internal welds over the previously primed areas. The costs of these materials shall be included in the unit rates for the supply of the pipes and specials.

The coating shall be applied in accordance with the manufacturer's instructions and with Appendices J and K of B.S. 3416.

Machinery- (Internal surfaces) e.g. pumps, valves, strainers, rising and suspension mains of wet well pumps:

As for cast iron and steel pipe work (Internal surfaces).

Cast iron and steel parts (External surfaces) immersed in Water:

All ungalvanised metal parts which will be immersed in water shall be cleaned by grit blasting and within four hours of blasting given an approved coating.

Cast iron and steel (External surfaces) in manholes and areas of high humidity.

Ungalvanised metal parts exposed in manholes or areas of high humidity shall be cleaned by grit blasting and given two coats of a black bituminous solution.

(b) Plant forwarded to site for final finishing.

Cast iron and steel parts (External surfaces) outside buildings:

All ungalvanised metal parts which will be exposed to the outside atmosphere shall be cleaned by grit blasting and provided with two coats of an approved primer.

Cast iron and steel parts inside buildings:

All exposed metal surfaces which will not be immersed in water or exposed in areas described above shall be rubbed down, cleaned by grit blasting and within four hours of blasting given one coat of an approved primer before packing.

9.5 Painting at Site

Immediately on arrival at the site, all items of plant shall be examined for damage to the paint coat applied at the manufacturer's works, and any damaged portions shall be cleaned down to the bare metal, all rust removed, and the paint coat made good with similar paint.

Steel and cast iron parts received at site shall be provided with adequate number of further coats of coal tar epoxy polyamine coating or Polyurethane coating as specified & approved, to a total dry film thickness of minimum 250 microns including the primer coats. All sharp edges, nuts, bolts and other items difficult to be painted shall receive a brush coat of specified paint before application of each coat of epoxy based paint giving a total dry film thickness of at least 250 microns. In the case of fabricated steelwork this work shall be done after assembly.

Before painting is commenced the Contractor shall submit for the approval of the Engineer, full details of the paints he proposes to use together with colour charts for the glossy finishes.

After erection, such items which are not finish painted shall be finish painted, items finish painted at the Manufacturer's works shall be touched up for any damaged paint work.

The painting work shall conform to the following requirements:

(a) The surface preparation shall be carried out generally in accordance with IS: 1477 Part I and IS: 6005
(b) After surface preparation, two coats of primer-red oxide zinc chromate with modified phenolic alkyd base conforming to IS: 2074 shall be applied. Dry film thickness of each coat shall be 25 microns.
(c) For finish painting, after application of primer as in (b) above, two coats of synthetic enamel conforming to IS: 2932 shall be applied. Dry film thickness of each coat shall be 25 microns.
d) Colours shall be selected as per IS: 5.

No painting shall be carried out unless the item has been inspected and accepted by Engineer at the Manufacturer's works

The dry paint film thickness shall be measured by Electrometer or other instruments approved by the Employer. In order to obtain the dry film thickness DFT specified, the Contractor shall ensure that the coverage rate given by the paint manufacturer will enable this thickness to be obtained. Strength of adhesion shall be measured with an adhesion tester and this value shall not be less than 10 kg/cm^2. Painted fabricated steel Work which is to be stored prior to erection shall be kept clear of the ground and shall be laid out or stacked in an orderly manner that will ensure that no. poles of water or dirt can accumulate on the surface. Suitable packings shall be laid between the stacked Materials. Where cover is provided, it shall be ventilated.

The painting procedure shall be submitted in the following format for approval:

(a) Surface Preparation
(b) Reference Standard
(c) Conditions of Work
(d) Type of Materials
(e) Tests and inspection methods and sequence, thickness (DFT)
(f) Colour in final coat.
(g) Total thickness of coats (DFT)
(h) Other necessary data and information

The following items in the plant are required to be painted.

(a) Outer surfaces of pumps, valves, pipes, fittings, motors etc., not exposed to treated water.
(b) Steelwork exposed to weather, such as outer surface of surge vessel, valves, pipes etc.
(c) Internal Plant and pipework, cranes, exhaust fans, fire extinguishers and miscellaneous steelwork not exposed to weather.
(d) Steelwork exposed to weather, such as platforms, ladders, hand railing, etc.
(e) Steelwork exposed to humid weather and requiring hard maintenance and repairs.
(f) Buried steelwork.
(g) Buried pipes and fittings prior to application of wrapping.
(h) Other equipment, as per requirement of employer.

All buried steel pipes and fittings shall be coated and unwrapped with hot or cold applied, self-adhesive, polyethylene in accordance with AWWA C214 or equivalent Standard.

Cast iron or mild steel parts to be built into concrete shall remain unpainted. Immediately before it is cast in-situ, it shall be made perfectly free from dirt, scale, loose rust, paint, oil limewash or any other coating.

No blast cleaning or painting shall be applied to corrosion resistant Materials such as stainless steels. Ni-resist cast iron, bronze and other metals used for seals, bearings, lighting fitting etc.

Machined surfaces such as gear teeth shall be coated with a thick layer of grease. Other mechanical surfaces such as shaft ends, or other bright parts shall be coated with two coats of an anti-rust solution which can be removed easily when required. Permanently bolted mechanical interfaces such as flanges shall be coated with a thin coat of anti-rust compound before assembly.

All primers, under coats and finishes shall be applied by brush or airless spray, except where otherwise specified.

Consecutive coats shall be in distinct but appropriate shades. All paints shall be supplied from the store to the painters, ready for application, and addition of thinners or any other Material shall be prohibited. Any instruction given by the paint manufacturer shall be strictly followed.

All painting shall be carried out by the painters under supervision. Paint shall be applied to the dry surface which has been prepared in compliance with the approved procedure.

No site painting shall be carried out unless the surface to be painted is dry, the air temperature above 4oC and the relative humidity less than 85%.

The Plant and equipment shall be inspected and reviewed at the various stages of the coating application both at the manufacturer's Works and at the Site of the Works. Samples may be taken from the paints as delivered and submitted to such tests as are deemed necessary. The completed paint systems shall be tested by instruments to ensure that the protection is of adequate thickness and is free from pinholes and the direct measurement of adhesion shall be checked by the removal of a small section of the coating. The Contractor shall supply all instruments and apparatus required for carrying out such tests required by the Employer.

9.6 Waterworks Finish

A high standard of finish, defined as "Waterworks finish" is required for all Plant as detailed below.

9.6.1 Welding and flame cutting

A smooth neat finish, by careful grinding if necessary is required on all exterior welding and flame cutting. All plates and bars used in fabrication shall have smooth surfaces with no pitting or deep slag inclusions

9.6.2 Castings

Casting surfaces shall be smooth and free from surface blowholes. Stock castings shall be specially selected with this in mind. All castings shall be shot blasted before machining.

9.6.3 Covers

All covers shall be firmly fixed. Weldmesh shall sit square in its frame. Where panels are placed next to each other the patterns shall line up.

9.6.4 Flanges and beadings

All bolt holes shall be spot faced parallel with the mating face for good seating of nuts and bolt heads. Surplus jointing shall be removed from mating faces and peripheries.

9.6.5 Items to be chromium plated.

Name plates, instruction plates, rotation arrows, indicators and pointers, small bore pipework, tundish oil level gauges and fittings, small valves (including air valves), plugs and grease nipples, which are sited in architecturally finished areas of the station and as selected by the Engineer, shall be chromium plated. Damage to chromium plating shall be made good.

All pipes and ittings etc., shall be fitted in a straight, neat symmetrical manner so as to present a pleasing appearance.

9.6.6 External screws, boltheads, nuts, and washers

These shall be chromium plated, sherardised, or made in stainless steel.

9.6.7 Gauges

All indicating gauges fitted to any machine assembly shall be of similar appearance and grouped together to present a pleasing aspect. They shall all have chromium plated cases, bezels, cocks and fittings.

9.6.8 Painting of Valves and Mechanical Equipment

a. Prior to Inspection

i. Surface Preparation: Sand Blasting to SA 2 ½ Grade – Near white blast cleaning.

ii. Application of Primer Coating after blast cleaning.

b. Post Inspection

i. Application of Intermediate Coat:

ii. The Valves shall be painted with Electro static epoxy powder coating both inside and outside with pocket less body passage for a minimum DFT of 250 Microns up to 1000 mm Diameter.

iii. Above 1000 mm diameter one coat of two component high build polyamide crude re-coatable epoxy coating to achieve DFT 150 micron.

iv. Application of Finish Coat:

One coat of two component aliphatic polyurethane finishes to achieve DFT 100 micron.

Total Painting DFT shall be minimum 250 microns.

End of Part 9

PART 10

Civil, Structural and Sewer Network Requirements

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CHAPTER 1

SITE CLEARANCE (CLEARING AND GRUBBING)

CHAPTER 1

SITE CLEARANCE (CLEARING AND GRUBBING)

1.1 Scope

This work shall consist of cutting, removing and disposing of all materials such as trees, bushes, shrubs, stumps, roots, grass, weeds, top organic soil not exceeding 150 mm in thickness, rubbish etc., from the area of works which in the opinion of the Engineer are unsuitable for incorporation in the works, and such areas as may be specified on the drawings or by the Engineer. It shall include necessary excavation, backfilling of pits resulting from uprooting of trees and stumps to required compaction, handling, salvaging, and disposal of cleared materials. Clearing and grubbing shall be performed in advance of earthwork operations and in accordance with the requirements of these specifications.

1.2 Preservation of Property/Amenities

Trees, shrubs, any other plants, pole lines, fences, signs, monuments, buildings, pipelines, sewers and all facilities within or adjacent to the site which are not to be disturbed shall be protected from injury or damage. The Contractor shall provide and install at his own expense, suitable safeguards approved by the Engineer for this purpose.

During clearing and grubbing, the Contractor shall take all necessary precautions to prevent soil erosion, water pollution, and other environmental impacts, and where required, undertake additional works to mitigate these effects, as specified in the relevant Clauses of Chapter 3. Before the start of operations, the Contractor shall submit to the Engineer for approval his work plan, including the procedure to be followed for disposal of waste materials, etc., and the schedules for carrying out temporary and permanent erosion control works as stipulated in Chapter 3.

1.3 Methods, Tools and Equipment

Only such methods, tools and equipment as are approved by the Engineer and which will not affect the property to be preserved shall be adopted for the Work. If the area has thick vegetation / roots / trees, a crawler or pneumatic-tyred dozer of adequate capacity may be used for clearance purposes. The dozer shall have ripper attachments for removal of tree stumps. All trees, stumps, etc., falling within excavation and fill lines shall be cut to such depth below ground level that in no case these fall within 500 mm of the subgrade / foundation / bed level. Also, all vegetation such as roots, under-growths, grass and other deleterious matter unsuitable for incorporation in the Work shall be removed between fill lines to the satisfaction of the Engineer. On the areas beyond these limits, trees and stumps required to be removed as directed by the Engineer shall be cut down to 1 m below ground level so that these do not present any unsightly appearance.

All branches of trees extending above the roadway shall be trimmed as directed by the Engineer.

All excavations below the general ground level resulting from the removal of trees, stumps, etc., shall be filled with suitable material and compacted thoroughly to ensure the surface at these points conforms to the surrounding area.
Ant-hills both above and below ground, which are liable to collapse and obstruct free subsoil water flow, shall be removed. Their workings, which may extend several meters, shall be suitably treated.

1.4 Disposal of Materials

All materials arising from clearing and grubbing operations shall be the property of Employer and shall be disposed of by the Contractor as directed by the Engineer.

Trunks and stumps of trees shall be cleaned of limbs and roots and stacked. Also boulders, stones and other materials usable in construction shall be neatly stacked as directed by the Engineer. Stacking stumps, boulders, stones etc., shall be done at specified spots with all lifts and lead.

All products of clearing and grubbing which, in the opinion of the Engineer, cannot be used or auctioned shall be cleared away from the site in a manner as directed by the Engineer. Care shall be taken to see that unsuitable waste materials are disposed off in such a manner that there is no likelihood of these getting mixed up with the materials meant for construction.

1.5 Measurements for Payment

Clearing and grubbing shall be measured on area basis in terms of hectares. Clearing and grubbing of borrow areas shall be deemed to be a part of Works preparatory to embankment construction and shall be deemed to have been included in the rates quoted for the embankment construction item and no separate payment shall be made for the same. Cutting of trees up to 300 mm in girth including removal of stumps and roots, and trimming of branches of trees extending above the roadway shall be considered incidental to the clearing and grubbing operations. Removal of stumps left over after trees have been cut by any other agency shall also be considered incidental to the clearing and grubbing operations.

Cutting, including removal of stumps and roots of trees of girth above 300 mm and backfilling to required compaction shall be measured in terms of number according to the sizes given below:

Above 300 mm to 600 mm;
Above 600 mm to 900 mm;
Above 900 mm to 1800 mm; and
Above 1800 mm.

For this purpose, the girth shall be measured at a height of 1 m above ground or at the top of the stump if the height of the stump is less than 1 m from the ground.

1.6 Rates

The Contract unit rates for the various items of clearing and grubbing shall be payment in full for carrying out the required operations, including full compensation for all labour, materials, tools, equipment, and incidentals necessary to complete the work. These will also include the removal of stumps of trees with a girth of less than 300 mm, as well as stumps left over after trees are cut by another agency. Additionally, this will involve excavation and backfilling to the required density, where necessary, and handling, salvaging, piling, and disposing of the cleared materials, including all lifts and leads.

The Contract unit rates for cutting (including removal of stumps and roots) of trees of girth above 300 mm shall include excavation and back-filling to required compaction, handling, salvaging, piling and disposing of the cleared materials with all lifts and lead.

Where a Contract does not include separate items of clearing and grubbing, the same shall be considered incidental to the earthwork items and the Contract unit prices for the same shall be considered as including clearing and grubbing operations.

End of Chapter-1

CHAPTER 2

DISMANTLING AND DEMOLITION

CHAPTER 2

DISMANTLING AND DEMOLITION

2.1 Scope

This work shall consist of removing, as hereinafter set forth, existing buildings, roofs, ceiling, flooring and paving, concrete and brick roofs and suspended floors, walls and columns, reinforced concrete and brick work, partitions, wood work, steel and iron work, doors and windows, pipes and sewer lines, posts or struts, fencing wire mesh, glazing, culverts, bridges, pavements, kerbs and other structures like guard-rails, utility services, catch basins, inlets, etc., which are in place but interfere with the new construction or are not suitable to remain in place, and of salvaging and disposing of the resulting materials and back filling the resulting trenches and pits.

Existing culverts, bridges, pavements, and other structures that are within the highway and that are designated for removal shall be removed up to the limits and extent specified in the Drawings or as indicated by the Engineer.

Dismantling and removal operations shall be carried out using suitable equipment and in a manner that leaves the adjacent pavement, structures, and any other work to be left in place undisturbed.

All operations necessary for the removal of any existing structure which might endanger new construction shall be completed prior to the start of new work.

2.2 Applicable Codes

IS: 1200-1974 (Part: XVIII)	Method of Measurements of Building and Civil Engineering Works - Demolition and Dismantling (Reaffirmed 2002) (3rd Revision).
IS: 4130-1991	Demolition of Buildings - Code of Safety (2nd Revision).

2.3 Terminology

The term ‘Dismantling’ implies carefully separating the parts without damage and removing. This may consist of dismantling one or more parts of the structure as specified.

The term ‘Demolition’ implies breaking up. This shall consist of demolishing whole or part of work including all relevant items as specified.

2.4 Buildings

2.4.1 Precautions

All materials obtained from dismantling or demolition shall be the property of the Employer unless otherwise specified and shall be kept in safe custody until they are handed over to the Engineer.

Demolition shall always be well-planned beforehand and generally be done in the reverse order in which the structure was constructed. The Engineer-In-Charge shall approve the operations before starting the work.

Due care shall be taken to maintain the safety measures prescribed in IS: 4130.

Necessary propping, shoring, and/or underpinning shall be provided to ensure the safety of the adjoining work or property before dismantling and demolition is undertaken, and the work shall be carried out in such a way that no damage is caused to the adjoining work or property. Wherever specified, temporary enclosures or partitions shall also be provided, as directed by the Engineer.

Necessary precautions shall be taken to minimize the dust nuisance.

Dismantling shall be done in a systematic manner. All materials which are likely to be damaged by dropping from a height or by demolishing roofs, masonry, etc., shall be carefully removed first. The dismantled articles shall be removed manually or otherwise, lowered to the ground (and not thrown) and then properly stacked as directed by the Engineer.

Where existing fixing is done by nails, screws, bolts, rivets, etc., dismantling shall be done by taking out the fixing with proper tools and not by tearing or ripping off.

Any serviceable material, obtained during dismantling or demolition, shall be separated out and stacked properly as directed by the Engineer within a lead of 50 m. All unserviceable materials rubbish etc. shall be disposed off as directed by the Engineer.

The Contractor shall maintain / disconnect existing services, whether temporary or permanent, where required by the Engineer.

2.4.2 Measurements

All work shall be measured net in the decimal system, as fixed in its place, subject to the following limits, unless otherwise stated hereinafter.

1. Dimensions shall be measured correct to a cm.
2. Areas shall be worked out in sq mt correct to two places of decimal.
3. Cubical contents shall be worked out to the nearest 0.01 cum.

Parts of the work that require dismantling and those that require demolition shall be measured separately.

Measurements of all works except hidden work shall be taken before demolition or dismantling and no allowance for increase in bulk shall be allowed.

Specifications for deduction for voids, openings etc. shall be on the same basis as that adopted for new construction of the work.
Work executed in the following conditions shall be measured separately:

1. Work in or under water and / or liquid mud;
2. Work in or under foul position.

2.4.3 Rates

The rate shall include the cost of all labour involved and tools used in demolishing and dismantling including scaffolding. The rate shall also include the charges for separating out and stacking the serviceable material properly and disposing off unserviceable material within a distance of 50 m.

The rate shall also include for temporary shoring for the safety of portions not required to be pulled down, or of adjoining property, and providing temporary enclosures or partitions, where considered necessary.

2.5 Roofs

Roof coverings generally including battens boarding, mats, bamboo jaffari or other subsidiary supports shall be measured in sq mt except lead sheet roof covering, which shall be measured in tonnes and stone slab roof covering which shall be measured in cum.

Ridges, hips and valleys shall be girthed and included with the roof area. Corrugated or semi corrugated surfaces shall be measured flat and not girthed.

Mud phuska on roofs shall be measured in cum.

Lead sheets in roofs shall be measured in tonnes and hips, valleys, flashings, lining to gutter etc. shall be included in this weight.

R.B. or R.C.C. roofs shall be measured in cum and if reinforcement is required to be salvaged, it shall be so stated. When reinforcement is required to be separated, scraped and cleaned, the work shall be measured separately as tonnes of salvaged steel.
Supporting members, such as rafters, purlins, beams joists, trusses etc. where of wood shall be measured in cum and steel or iron sections in tonnes.

2.6 Ceiling

The stripping of ceilings shall be measured in sqm.

Dismantling of supporting joists, beams, etc. shall be measured in cum or in tonnes.

Height above floor levels if it exceeds 3.5 m shall paid for separately.

2.7 Flooring and Paving

Dismantling of floors (except concrete and brick floors) shall be measured in sqm. Supports such as joints, beams etc. if any shall be measured as per Clause 2.5. Concrete and bricks paving shall be measured as per Clause 2.8.

2.8 Concrete and Brick Roofs and Suspended Floors

Demolition of floors and roofs of concrete or brick shall be measured in cum. Beams cantilevers or other subsidiary supports of similar materials shall be included in the item. In measuring thickness of roofs provided with water proofing treatments with bitumen, felts, the thickness of water proofing treatment shall be ignored.

2.9 Walls and Piers

Taking down walls and independent piers or columns of brick, stone or concrete shall be measured, in cum. All copings, corbels, cornices and other projections shall be included with the wall measurements.
In measuring thickness of plastered walls, the thickness of plaster shall be ignored.

Ashlar face stones, dressed stone work, precast concrete articles, etc. if required to be taken down intact shall be so stated, and measured separately in cum.

Cleaning bricks stacking for measurements including all extra handling and removal and disposing off the rubbish as stated shall be enumerated in thousand of cleaned bricks.

Cleaning stone obtained from demolished / dismantling stone masonry of any description including ashlar facing dressed stone work, stone slabs or flagging and precast concrete blocks including all extra handling and disposing of the rubbish as stated shall be measured in cum of cleaned stone.

Honey comb works or cavity walls of bricks stone or concrete shall be measured as solid.

2.10 Reinforced Concrete and Brick Work

Reinforced concrete structures and reinforced brick roof and walls shall be measured in cum and if reinforcement is required to be salvaged, it shall be so stated.

Where reinforcement is required to be separated, scraped and cleaned, the work shall be measured separately in tonnes of salvaged steel.

2.11 Partitions, Trellis Work, Etc.

Partitions or light walls of lath and plaster, trellis work, expanded metal, thin concrete or terracotta slabs and other similar materials including frame work if any shall be measured in sqm stating the overall thickness.

2.12 Wood Work

All wood work including karries average 40 sq cm or over in section, shall be measured in cum, while that under 40 sq cm in section, in running metres. Ballies shall be measured in running metres.
Boarding including wooden chajjas and sun shades along with supports shall be measured in square m in its plane.

2.13 Steel and Iron Work

All steel and iron work shall be measured in tonnes. The weight shall be computed from standard tables unless the actual weight can readily be determined.
Riveted work, where rivets are required to be cut, shall be measured separately.

Marking of structural steel required to be re-erected shall be measured separately.

In framed steel items, the weight or any covering material or filling such as iron sheets and expanded metal shall be included in the weight of the main article unless such covering is not ordered to be taken out separately.

2.14 Doors and Windows

Dismantling of doors, windows, clerestory windows, ventilators etc. (Wood or metal) whether done separately or along with removal of wall by making recess in the wall shall be enumerated. Those exceeding 3 sqm each in area shall be measured separately. The item shall include removal of chowkhats architraves, hold fasts and other attachments.

If only shutters are to be taken out it shall be measured separately.

2.15 Pipes and Sewer Lines

Water pipe lines including rain water pipes with clamps and specials, sewer lines (salt glazed ware or concrete) etc. shall be described by their diameter and length measured in running metre(RM) inclusive of joints.

If the joints, special and fittings etc. are required to be separated, it shall be so stated and enumerated.

Pucca drains shall be measured under relevant items.

Value cistern, public fountain platform, fire hydrants, etc. shall be enumerated.

Machine holes and inspection chambers shall be enumerated stating the size and depth of Machine hole/inspection chamber. They shall be classified into different groups depending upon the depth, in unit of half and one metre depth. The depth of the Machine hole shall be the distance between the top of Machine hole cover and invert level of the drain.

Ventilating shafts, gully traps, flushing cisterns and other appurtenant items of work shall be enumerated.

2.16 Posts or Struts

Posts or struts (wood, steel or RCC) section including taking out embedded portion shall be measured in running metre.

2.17 Fencing Wire Mesh

Wire mesh fencing of any type with frame shall be measured in square metre.

2.18 Glazing

Taking out any portion of serviceable glass except polished plate, from old sashes, skylights, etc. (any thickness, weight or size) raking out old putty, etc. shall be measured in square metre.

Irregular or circular panes shall be measured as rectangle or square enveloping the same, the width and height being measured correct to the nearest 0.5 cm.

2.19 Dismantling Culverts, Bridges and Other Structures/Pavements

2.19.1 Dismantling Culverts and Bridges

The structures shall be dismantled carefully and the resulting materials so removed as not to cause any damage to the serviceable materials to be salvaged, the part of the structure to be retained and any other properties or structures nearby.

Unless otherwise specified, the superstructure portion of culverts / bridges shall be entirely removed and other parts removed below the ground level or as necessary depending upon the interference they cause to the new construction. Removal of overlaying or adjacent material, if required in connection with the dismantling of the structures shall be incidental to this item.

Where existing culvert / bridges are to be extended or otherwise incorporated in the new work, only such part or parts of the exiting structure shall be removed as are necessary and directed by the Engineer to provide a proper connection to the new work. The connecting edges shall be cut, chipped and trimmed to the required lines and grades without weakening or damaging any part of the structure to be retained. Due care should be taken to ensure that reinforcing bars which are to be left in place to project into the new work as dowels or ties are not injured during removal of concrete.

Pipe culverts shall be carefully removed in such manner as to avoid damage to the pipes.

Steel structures shall, unless otherwise provided, be carefully dismantled in such a manner as to avoid damage to members thereof. If specified in the Drawings or directed by the Engineer that the structure is to be removed in a condition suitable for re-erection, all members shall be match-marked by the Contractor with white lead paint before dismantling; end pins, nuts, loose plates, etc., shall be similarly marked to indicate their proper location; all pins, pin holes and machined surfaces shall be painted with a mixture of white lead and tallow and all loose parts shall be securely wired to adjacent members or packed in boxes.
Timber structures shall be removed in such a manner as to avoid damage to such timber or lumber when designated by the Engineer to be salvaged.

2.19.2 Dismantling Pavements and Other Structures

In removing pavements, kerbs, gutters and other structures like guard-rails, fences, Machine holes, catch-basins, inlets, etc. where portions of the existing construction are to be left in the finished work, the same shall be removed to an existing joint or cut and chipped to a true line with a face perpendicular to the surface of the existing structure. Sufficient removal shall be made to provide for proper grades and connections with the new work as directed by the Engineer.

All concrete pavements, base courses in carriageway and shoulders etc., designated for removal shall broken to pieces whose volume shall not exceed 0.02 cum and stockpiled at designated locations if the material is to be used later or otherwise arranged for disposal as directed (see Clause 2.19.4).

2.19.3 Back-filling

Holes and depressions caused by dismantling operations shall be backfilled with excavated or other approved materials and compacted to required density as directed by the Engineer.

2.19.4 Disposal of Materials

All materials obtained by dismantling shall be the property of Employer. Unless otherwise specified, materials having any salvage value shall be placed in neat stacks of like materials within the right-of-way, as directed by the Engineer with all lifts and up to a lead of 1000 m.

Pipe culverts that are removed shall be cleaned and neatly piled on the right-of-way at points designated by the Engineer with all lifts and lead up to 1000 m.

Structural steel removed from old structures shall, unless otherwise specified or directed, be stored in a neat and presentable manner on blocks in locations suitable for loading. Structures or portions thereof which are specified in the Contract for re-erection shall be stored in separate piles.

Timber or lumber from old structures which is designated by the Engineer as materials to be salvaged shall have all nails and bolts removed there from and shall be stored in neat piles in locations suitable for loading.

All materials obtained from dismantling operations which, in the opinion of the Engineer, cannot be used or auctioned shall be disposed of as directed by the Engineer with all lifts and up to a lead of 1000 m.

2.19.5 Measurements for Payment

The work of dismantling structures shall be paid for in units indicated below by taking measurements before and after, as applicable:

1.	Dismantling brick/stone masonry/concrete (plain and reinforced)	cum.
2.	Dismantling flexible and cement concrete pavement	cum.
3.	Dismantling steel structures	tonne
4.	Dismantling timber structures	cum.
5.	Dismantling pipes, guard rails, kerbs, gutters and fencing	linear m.
6.	Utility services	Nos.

2.19.6 Rates

The Contract unit rates for the various items of dismantling shall be paid in full for carrying out the required operations including full compensation for all labour, materials, tools, equipment, safeguards and incidentals necessary to complete the work. These will also include excavation and backfilling where necessary to the required compaction and for handling, salvaging, piling and disposing of the dismantled materials within all lifts and up to a lead of 1000 m.

End of Chapter-2

CHAPTER 3

EARTHWORKS

CHAPTER 3

EARTHWORKS

3.1 Applicable Codes

The following Indian Standard Codes, unless otherwise specified herein, shall be applicable. In all cases, the latest revision of the codes shall be referred to.

a) IS 783 - 1985 - (Reaffirmed 2017) Code of practice for laying of Concrete pipes.
IS 4984 - 1995 - (Reaffirmed 2016) Code of practice for laying of HDPE pipes.
IS 12288 - 1987 - (Reaffirmed 2017) Code of practice for use and laying of DI pipes.

b) IS 3764 - 1992 - (Reaffirmed 2017) Excavation work - Code of Safety.

c) IS 2720 - Methods of test for soils:
(Part-1) - 1983 - (Reaffirmed 2015) Preparation of dry soil samples for various tests.
(Part-2) - 1973 - (Reaffirmed 2015) Determination of Water Content.
(Part-4) - 1985 - (Reaffirmed 2015) Grain size analysis.
(Part-5) - 1985 - (Reaffirmed 2015) Determination of liquid and plastic limit.
(Part-7) - 1980 - (Reaffirmed 2016) Determination of water content - dry density relation using light compaction.
(Part-9) - 1992 - (Reaffirmed 2016) Determination of dry density - moisture content by constant weight of soil method.
(Part-14) - 1983 - (Reaffirmed 2015) Determination of density index (relative density) Cohesionless soils.
(Part-22) - 1972 - (Reaffirmed 2015) Determination of organic matter.
(Part-26) - 1987 - (Reaffirmed 2016) Determination of pH Value.
(Part-27) - 1977 - (Reaffirmed 2015) Determination of total soluble sulphates.
(Part-28) - 1974 - (Reaffirmed 2015) Determination of dry density of soils in place, by the sand replacement method.
(Part-33)-1971 - (Reaffirmed 2015) Determination of the density in place by the ring and water replacement method.

(Part-34) - 1972- (Reaffirmed 2015)	Determination of density of soil in place by rubber balloon method.
(Part-38) - 1976- (Reaffirmed 2016)	Compaction control test (Hilf Method).

3.2 Drawings

Engineer will furnish drawings wherever, in his opinion, such drawings are required to show areas to be excavated/filled grade level, sequence of priorities etc. Contractor shall strictly follow such drawings.

3.3 General

The Contractor shall furnish all tools, plant, instruments, qualified supervisory personnel, labour, materials, any temporary works, consumables, any and everything necessary, whether or not such items are specifically stated herein for completion of the work in accordance with the Specifications.

The Contractor shall survey the site before excavation and set out all lines and establish levels for various works such as grading, basement, foundations, plinth filling, roads, drains, cable trenches, pipelines etc. Such survey shall be carried out by taking accurate cross sections of the area perpendicular to established reference/grid lines at 8m intervals or nearer, if necessary, based on ground profile and thereafter properly recorded.

The excavation shall be carried out to correct lines and levels. This shall also include, where required, proper shoring to maintain excavations and also the furnishing, erecting and maintaining of substantial barricades around excavated areas and warning lamps at night.

The rates quoted shall also include for dumping of excavated material in regular heaps, bunds, riprap with regular slopes within the lead specified and levelling the same so as to provide natural drainage. Rock/soil excavated shall be stacked properly as approved by the Engineer. As a rule, all softer material shall be laid along the center of heaps, the harder and more weather resisting materials forming the casing on the sides and the top. Rock shall be stacked separately.

Topsoil shall be stock piled separately for later re-use.

3.4 Clearing

The area to be excavated/filled shall be cleared of fences, trees, plants, logs, stumps, bush, vegetation, rubbish, slush, etc. and other objectionable matter. If any roots or stumps of trees are encountered during excavation, they shall also be removed. The material so removed shall be disposed off as approved by the Engineer. Where earth fill is intended, the area shall be stripped of all loose/ soft patches, top soil containing objectionable matter/ materials before fill commences.

3.5 Classification

All materials to be excavated shall be classified by Engineer, into one of the following classes and shall be paid for at the rate tendered for that particular class of material. No distinction shall be made whether the material is dry, moist or wet. The decision of Engineer regarding the classification of the material shall be final and binding on Contractor and not be a subject matter of any appeal or arbitration.

Any earthwork will be classified under any of the following categories:

a) Ordinary & Hard Soils

These shall include all kinds of soils containing kankar, sand, silt, moorum and/or shingle, gravel, clay, loam, peat, ash, shale, etc., which can generally be excavated by spade, pick axes and shovel, and which is not classified under "soft and decomposed rock" and "hard rock" defined below. This shall also include embedded rock boulders not longer than 1 metre in any one direction and not more than 200 mm in any one of the other two directions.

b) Soft and Decomposed Rock

This shall include rock, boulders, slag, chalk, slate, hard mica schist, laterite, highly weathered granite gneiss and all other materials which in the opinion of Engineer is rock, but does not need blasting and could be removed readily with picks, hammer, crow bars, wedges, and pneumatic breaking equipment. The mere fact that Contractor resorts to blasting for reasons of his own, shall not qualify for classification under 'hard rock'.

This shall also include excavation in macadam and tarred roads and pavements. This shall also include rock boulders not longer than 1 metre in any direction and not more than 500 mm in any one of the other two directions. Masonry to be dismantled will also be measured under this item.

c) Hard Rock

This shall include all rock occurring in large continuous masses which cannot be removed except by blasting, chiselling or by drilling with heavy mechanical breakers. Harder varieties of rock with or without veins and secondary minerals which, in the opinion of Engineer require blasting shall be considered as hard rock. Boulders of rock occurring in such sizes and not classified under (a) and (b) above shall also be classified as hard rock. Concrete work both reinforced and unreinforced to be dismantled will be measured under this item, unless a separate provision is made in the Schedule of Quantities.

Before classification of material as rock the Contractor shall demonstrate to the satisfaction of the Employer's Representative his inability to excavate it without resort to heavy percussion tools complete with rock bits, hydraulic wedges or blasting. Excavation by the use of explosive will not normally be permitted.

Material shall not be classified as rock unless the Employer's Representative has agreed to such classification on the basis of such a demonstration before its excavation. Excavations where rock has been encountered and classified as such shall not be backfilled before

examination of the excavated faces by the Employer's Representative to enable the extent of the rock excavation to be determined.

3.6 Excavation

All excavation work shall be carried out by mechanical equipment unless, in the opinion of Engineer, the work involved requires it to be carried out by manual methods.

Excavation for permanent work shall be taken out to such widths, lengths, depths and profiles as are shown on the drawings provided by the Contractor or such other lines and grades as may be agreed with the Engineer. Rough excavation shall be carried out to a depth of 150mm above the final level. The balance shall be excavated with special care. Soft pockets shall be removed below the final level and extra excavation filled up with lean concrete of grade M10 with 20 mm downgraded aggregates as approved by the Engineer. The final excavation should be carried out just prior to laying the blinding course.

Contractor may, for facility of work or similar other reasons excavate, and also backfill later, if so approved by Engineer, at his own cost outside the lines shown on the drawings or directed by Engineer. Should any excavation be taken below the specified elevations, Contractor shall fill it up, with concrete of the same class as in the foundation resting thereon, upto the required elevation. No extra shall be claimed by Contractor on this account.

All excavations shall be to the minimum dimensions required for safety and ease of working. Prior approval of the Engineer shall be obtained by the Contractor in each individual case, for the method proposed for the excavation, including dimensions, side slopes, dewatering, disposal, etc. This approval shall not in any way relieve the Contractor of his responsibility for any consequent loss or damage. The excavation must be carried out in the most expeditious and efficient manner. Side slopes shall be as steep as will stand safely for the actual soil conditions encountered. Every precaution shall be taken to prevent slips. Should slips occur, the slipped material shall be removed and the slope dressed to a modified stable slope. Removal of the slipped earth will not be paid for if the slips are due to the negligence of Contractor.

3.7 Stripping Loose Rock

All loose boulders, detached rocks partially and other loose material which might move therewith not directly in the excavation but so close to the area to be excavated as to be liable, in the opinion of Engineer, to fall or otherwise endanger the workmen, equipment, or the work shall be stripped off and removed from the area of the excavation. The method used shall be such as not to render unstable or unsafe the portion which was originally sound and safe.

Any material not requiring removal in order to complete the permanent works, but which, in the opinion of Engineer, is likely to become loose or unstable later, shall also be promptly and satisfactorily removed. The cost of such stripping will be paid for at the unit rates accepted for the class of materials in question.

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3.8 Excavation in Hard Rock

3.8.1 General Requirements

Unless otherwise stated herein, I.S Specification "IS- 4081(1986) Safety code for Blasting and related Drilling Operations" shall be followed. After removal of overburden, if any, excavation shall be continued in rock to such widths, lengths, depths and profiles as are shown on the drawings or such other lines and grades as may be specified by the Engineer. As far as possible all blasting shall be completed prior to commencement of construction. At all stages of excavation, precautions shall be taken to preserve the rock below and beyond the lines specified for the excavation, in the soundest possible condition. The quantity and strength of explosive used shall be such as will neither damage nor crack the rock outside the limits of excavation. All precautions, as directed by the Engineer, shall be taken during the blasting operations and care shall be taken that no damage is caused to adjoining buildings or structure as a result of blasting operations. In case of damage to permanent or temporary structures, Contractor shall repair the same to the satisfaction of the Engineer at his cost. As excavation approaches its final lines and levels, the depth of the charge holes and amount of explosives used shall be progressively and suitably reduced.

Specific permission of the Engineer will have to be taken by Contractor for blasting rock and he shall also obtain a valid Blasting License from the authorities concerned. If permission for blasting is refused by the Engineer, the rock shall be removed by wedging, pick, barring, heating and quenching or other approved means. All loose or loosened rock in the sides shall be removed by barring, wedging, etc. The unit rate for excavation in hard rock shall include the cost of all these operations.

Contractor shall obtain necessary license for storage of explosives, fuses and detonators issued to him from Employer's stores or from supplier arranged by him, from the authorities dealing with explosives. The fees, if any, required for obtaining such license, shall be borne by Contractor. Contractor shall have to make necessary storage facilities for the explosives etc. as per rules of local, State and Central Government authorities and Statutory bodies/regulations. Explosives shall be kept dry and shall not be exposed to direct rays of sun or be stored in the vicinity of fire, stoves, steam pipes or heated metal, etc. No explosive shall be brought near the work in excess of quantity required for a particular amount of firing to be done; and surplus left after filling the holes shall be removed to the magazine. The magazine shall be built as for as possible away from the area to be blasted, Engineer's prior approval shall be taken for the location proposed for the magazine.

In no case shall blasting be allowed closer than 30 metres to any structure or to locations where concrete has just been placed. In the latter case the concrete must be at least 7 days old.

Excavation in hard rock shall be only by chiseling / Jack hammering or by drilling with mechanical breakers.

The rock shall be removed by wedging, pick, boring, heating and quenching or other approved non-blasting methods. All loose or loosened rock in the sides shall be removed by barring, wedging etc. The unit rate for excavation in hard rock shall include the cost of all these operations. No blasting is allowed.

3.8.2 Specific Requirements

For blasting operations, the following points shall be observed.

Contractor shall employ a competent and experienced supervisor and licensed blaster in-charge of each set of operation, who shall be held personally responsible to ensure that all safety regulations are carried out.

Before any blasting is carried out, Contractor shall intimate Engineer and obtain his approval in writing for resorting to such operations. He shall intimate the hours of firing charges, the nature of explosive to be used and the precautions taken for ensuring safety.

Contractor shall ensure that all workmen and the personnel at site are excluded from a area within 200 m. radius from the firing point, at least 5 minutes before firing time by sounding warning whistle. The area shall also be given warning by sounding a distinguishing whistle.

The blasting of rock near any existing buildings, equipment or any other property shall be done under cover if permitted by the Engineer and Contractor has to make all such necessary muffling arrangements. Covering may preferably be done by M.S. plates with adequate dead weight over them. Blasting shall be done with small charges only and where directed by Engineer, a trench shall have to be cut by chiseling prior to the blasting operation separating the area under blasting from the existing structures.

The firing shall be supervised by a Supervisor and not more than 6 (six) holes at a time shall be set off successively. If the blasts do not tally with the number fired, the misfired holes shall be carefully located after half an hour and when located, shall be exploded by drilling a fresh hole along the misfired hole (but not nearer than 600 mm from it) and by exploding a new charge.

A wooden tamping rod with a flat end shall be used to push cartridges home and metal rod or hammer shall not be permitted. The charges shall be placed firmly into place and not rammed or pounded. After a hole is filled to the required depth, the balance of the hole shall be filled with stemming which may consist of sand or stone dust or similar inert material.

Contractor shall preferably detonate the explosives electrically.

The explosives shall be exploded by means of a primer which shall be fired by detonating a fuse instantaneous detonator (F.I.D) or other approved cables. The detonators with F.I.D shall be connected by special nippers.

In dry weather and normal dry excavation, ordinary low explosive gunpowder may be used. In damp rock, high explosive like gelatine with detonator and fuse wire may be used. Under or for excavation in rock with substantial accumulated seepage electric detonation shall be used.

Holes for charging explosive shall be drilled with pneumatic drills, the drilling pattern being so planned that rock pieces after blasting will be suitable for handling without secondary blasting.

When excavation has almost reached the desired level, hand trimming shall have to be done for dressing the surface to the desired level. Any rock excavation beyond an overbreak limit of 75 mm shall be filled up as instructed by Engineer, with concrete of strength not less than M10. The cost of filling such excess depth shall be borne by Contractor and the excavation carried out beyond the limit specified above will not be paid for. Stopping in rock excavation shall be done by hand trimming.

Contractor shall be responsible for any accident to workmen, public or Employer's property due to blasting operations. Contractor shall also be responsible for strict observance of rules, laid by Inspector of Explosives, or any other Authority duly constituted under the State and /or Union Government.

3.9 Fill, Backfilling and Site Grading

3.9.1 General

All fill material shall be subject to the Engineer's approval. If any material is rejected by Engineer, the Contractor shall remove the same forthwith from the site. Surplus fill material shall be deposited/disposed off as directed by Engineer after the fill work is completed.

No earth fill shall commence until surface water discharges and streams have been properly intercepted or otherwise dealt with to the approval of the Engineer.

The Contractor shall not commence the placement of any fill or backfill at any location without the approval of the Engineer.

3.9.2 Material

To the extent available, selected surplus soils from excavations shall be used as backfill. Backfill material shall be free from lumps, organic or other foreign material. All lumps of earth shall be broken or removed. Where excavated material is mostly rock, the boulders shall be broken into pieces not larger than 150 mm size, mixed with properly graded fine material consisting of murum or earth to fill the voids and the mixture used for filling.

If fill material is required to be imported, the Contractor shall make arrangements to bring such material from outside borrow pits. The material and source shall be subject to the prior approval of the Engineer. The approved borrow pit areas shall be cleared of all bushes, roots of trees, plants, rubbish, etc. Top soil containing foreign material shall be removed. The materials so removed shall be disposed off as directed by Engineer. The Contractor shall provide the necessary access roads to borrow areas and maintain the same if such roads do not exist, at his cost.

3.9.3 Filling in pits and trenches around foundations of structures, walls, etc.

As soon as the work in foundations has been accepted and measured, the spaces around the foundations, structures, pits, trenches, etc., shall be cleared of all debris and filled with earth in layers not exceeding 15 cm, each layer being watered, rammed and properly consolidated, before the succeeding one is laid. Each layer shall be consolidated to the satisfaction of

Engineer. Earth shall be rammed with approved mechanical compaction machines. Usually no manual compaction shall be allowed unless the Engineer is satisfied that in some cases manual compaction by tampers cannot be avoided. The final backfill surface shall be trimmed and leveled to a proper profile to the approval of the Engineer.

3.9.4 Plinth Filling

Plinth filling shall be carried out with approved material as described hereinbefore in layers not exceeding 15cm, watered and compacted with mechanical compaction machines. The Engineer may, however, permit manual compaction by hand tampers where he is satisfied that mechanical compaction is not possible. When filling reaches the finished level, the surface shall be flooded with water, unless otherwise directed, for at least 24 hours, allowed to dry and then the surface again compacted as specified above to avoid settlement at a later stage. The finished level of the filling shall be trimmed to the level/slope specified.

Compaction of the plinth fill shall be carried out by means of 12 ton rollers smooth wheeled, sheep-foot or wobbly wheeled rollers. In case of compaction of granular material such as sands and gravel, vibratory rollers shall be used. A smaller weight roller may be used only if permitted by the Engineer. As rolling proceeds, water sprinkling shall be done to assist consolidation. Water shall not be sprinkled in case of sandy fills.

The thickness of each unconsolidated fill layer can in this case be upto a maximum of 300mm. The Contractor will determine the thickness of the layers in which fill has to be consolidated depending on the fill material and equipment used and the approval of the Engineer obtained prior to commencing filling.

Rolling shall commence from the outer edge and progress towards the centre and continue until compaction is to the satisfaction of Engineer, but in no case less than 10 passes of the roller will be accepted for each layer.

The compacted surface shall be properly shaped, trimmed and consolidated to an even and uniform gradient. All soft spots shall be excavated, then filled and consolidated.

At some locations/areas, it may not be possible to use rollers because of space restrictions, etc. The Contractor shall then be permitted to use pneumatic tampers, rammers, etc. and he shall ensure proper compaction.

3.9.5 Sand Filling in Plinth and Other Places

Where backfilling is required to be carried out with local sand it shall be clean, medium grained and free from impurities. The filled-in-sand shall be kept flooded with water for 24 hours to ensure maximum consolidation. Any temporary work required to contain sand under flooded condition shall be on Contractor’s account. The surface of the consolidated sand shall be dressed to required level or slope. Construction of floors or other structures on sand fill shall not be started until the Engineer has inspected and approved the fill.

3.9.6 Filling in Trenches

Filling in trenches for pipes and drains shall be commenced as soon as the joints of pipes and drains have been tested and passed. The backfilling material shall be properly consolidated by watering and ramming, taking due care that no damage is caused to the pipes.

Where the trenches are excavated in soil, the filling from the bottom of the trench to the level of the centre line of the pipe shall be done by hand compaction with selected approved earth in layers not exceeding 8 cm; backfilling above the level of the centre line of the pipes shall be done with selected earth by hand compaction, or other approved means in layers not exceeding 15 cm.

In case of excavation of trenches in rock, the filling upto a level 30 cm above the top of the pipe shall be done with fine materials such as earth, murum, etc. The filling up to the level of the centre line of the pipe shall be done by hand compaction in layers not exceeding 8 cm whereas the filling above the centre line of the pipe shall be done by hand compaction or approved means in layers not exceeding 15 cm. The filling from a level 30 cm above the top of the pipe to the top of the trench shall be done by hand or other approved mechanical methods with broken rock filling of size not exceeding 15 cm mixed with fine material as available to fill up the voids.

Filling of the trenches shall be carried out simultaneously on both sides of the pipe to avoid unequal pressure on the pipe.

In the case of water transmission, pipe lines works etc for water transfer, the Contractor shall take proper precautions against the risks of floatation. Should any section of the pipeline be affected by floatation in the course of works the entire work shall be removed and then reinstalled to the satisfaction of Engineer.

3.10 General Site Grading

Site grading shall be carried out as indicated in the drawings and as approved by the Engineer. Excavation shall be carried out as specified in the Specifications. Filling and compaction shall be carried out as specified under Clause 3.9 and elsewhere unless otherwise indicated below.

The fill has to be compacted in layers not exceeding 225 mm and leveled uniformly and compacted as indicated in Clause 3.9 before the next layer is deposited.

To ensure that the fill has been compacted as specified, field and laboratory tests shall be carried out by the Contractor at his cost.

Field compaction tests shall be carried out in each layer of filling until the fill to the entire height has been completed. This shall hold good for embankments as well. The fill will be considered as incomplete if the desired compaction has not been obtained.

The Contractor shall protect the earth fill from being washed away by rain or damaged in any other way. Should any slip occur, the Contractor shall remove the affected material and make good the slip at his cost.

If so specified, the rock as obtained from excavation may be used for filling and leveling to indicate grades without further breaking. In such an event, filling shall be done in layers not exceeding 50 cms approximately. After rock filling to the approximate level, indicated above has been carried out, the void in the rocks shall be filled with finer materials such as earth, broken stone, etc. and the area flooded so that the finer materials fill up the voids. Care shall be taken to ensure that the finer fill material does not get washed out. Over the layer so filled, a 100 mm thick mixed layer of broken material and earth shall be laid and consolidation carried out by a 12 ton roller. No less than twelve passes of the roller shall be accepted before subsequent similar operations are taken up.

3.11 Fill Density

The compaction, where so called for, shall comply with minimum 95% Modified Proctor density at moisture content differing not more than 4% from the optimum moisture content. The Contractor shall demonstrate adequately by field and laboratory tests that the specified density has been obtained.

3.12 Lead

Lead for deposition/disposal of excavated material, shall be as specified in the respective item of work. No extra compensation is admissible on the grounds that the lead including that for borrowed material had to be transported over marshy or 'katcha' land/route.

3.13 Measurement and Payment

All excavation shall be measured net. Dimensions for purpose of payment shall be reckoned on the horizontal area of the excavation at the base for foundations of the walls, columns, footings, tanks, rafts or other foundations/structures to be built, multiplied by the mean depth from the surface of the ground in accordance with the drawings. Excavations in side slopes will not be paid for. Contractor may make such allowance in his rates to provide for excavation in side slopes keeping in mind the nature of the soil and safety or excavation. Reasonable working space, beyond concrete dimensions and shuttering where considered necessary in the opinion of Engineer will be allowed in excavation and considered for payment. However, if concreting is proposed against the excavated sides, no such over-excavation will be permitted. In such cases over-excavation shall be made good by Contractor with concrete of the same class as in the foundations at his cost.

In the case of water transmission, pipelines works etc for water transfer trench excavation shall be measured using the dimensions detailed in the standard section shown on the Drawings. No payment will be made for working space except where clearly mentioned on the drawings. Excavation beyond the widths or depths required will not be paid for any additional concrete or bedding material required as a result of over-excavation at the Contractor's expense.

Backfilling as per specification the sides of foundations of columns, footings, structures, walls, tanks, rafts, trenches etc. with excavated material will not be paid for separately. It shall be clearly understood that the rate quoted for excavation including backfilling shall include stacking of excavated material as directed, excavation/packing of selected stacked material, conveying it to the place of final backfill, compaction etc. as specified. As a rule, material to be backfilled shall be stacked temporarily within the site as directed by the Engineer

Payment for fill inside trenches, plinth or similar filling with selected excavated material will be made for only compaction as specified/directed. Cost of all other operations shall be deemed to have been covered in the rate quoted for excavation. Payment for this work will be made based on measurement of plinth/trench dimensions as per drawings. The plinth ground levels shall be surveyed beforehand for this purpose. If no compaction is specified/desired such filling will not be separately paid for. In such an event the fill shall be leveled/finished to the profile as directed at no extra cost.

Backfilling, plinth filling etc. with borrowed earth will be paid for at rates quoted. The quoted rate shall include all operations such as clearing, excavation, lead and transport, fill, compaction etc, as specified. Actual quantity of consolidated filling or actual quantity or excavation in the borrow pits (less such top soil which has been excavated and not used for filling) whichever is less shall be measured and paid for in cubic meters. The lead, lift etc. shall be as indicated in the schedule of quantities.

Actual quantity of consolidated sand filling shall be measured and paid in cubic meters.

Volume of rock excavated shall be calculated on the basis of length, breadth and depth of excavation indicated on the drawings. No payment will be made for excavations/over break beyond payment line specified. Where such measurement is not possible as in the case of strata intermixed with soil, excavated rock shall be properly stacked as directed by Engineer and the volume of rock calculated on the basis of stack measurements after making appropriate allowance for voids. The allowance to be made for voids shall be decided by Engineer and this will not be a subject matter of dispute or appeal.

3.14 Timber Shoring

Close timbering shall be done by completely covering the sides of the trenches and pits generally with short, upright members called 'polling boards'. These shall be of minimum 25 cm x 4 cm sections or as approved by the Engineer. The boards shall generally be placed in position vertically side by side without any gap on each side of the excavation and shall be secured by horizontal walling of strong wood at maximum 1.2 meter spacing's, strutted with ballies or as approved by the Engineer. The length of the ballie struts shall depend on the width of the trench or pit. If the soil is very soft and loose, the boards shall be placed horizontally against each side of the excavation and supported by vertical walling, which in turn shall be suitably strutted. The lowest boards supporting the sides shall be taken into the ground and no portion of the vertical side of the trench or pit shall remain exposed, so as to render the earth liable to slip out.

Timber shoring shall be 'close' or 'open' type, depending on the nature of soil and the depth of pit or trench. The type of timbering shall be as approved by the Engineer. It shall be the responsibility of the Contractor to take all necessary steps to prevent the sides of excavations, trenches, pits, etc. from collapsing.

Timber shoring may also be required to keep the sides of excavations vertical to ensure safety of adjoining structures or to limit the slope of excavations, or due to space restrictions or for other reasons. Such shoring shall be carried out, except in an emergency, only under instructions from the Engineer.

The withdrawal of the timber shall be done carefully to prevent the collapse of the pit or trench. It shall be started at one end and proceeded with, systematically to the other end. Concrete or masonry shall not be damaged during the removal of the timber.

In the case of open timbering, the entire surface of the side of trench or pit is not required to be covered. The vertical boards of minimum 25 cm x 4 cm sections shall be spaced sufficiently apart to leave unsupported strips of maximum 50 cm average width. The detailed arrangement, sizes of the timber and the spacings shall be subject to the approval of the Engineer. In all other respects, the Specifications for close timbering shall apply to open timbering.

In case of large pits and open excavations, where shoring is required for securing safety of adjoining structures or for any other reasons and where the planking across sides of excavations/pits cannot be strutted against, suitable inclined struts supported on the excavated bed shall be provided. The load from such struts shall be suitably distributed on the bed to ensure no yielding of the strut. If however, Engineer directs any timbering to be left-in, keeping in mind the type of construction or any other factor, Contractor shall be paid for at the scheduled item rate for such left-in timbering.

3.15 Measurement

Unless separately provided for in the Schedule of Quantities, the actual effective area of shored faces as approved by Engineer shall be measured in sq.m. The area of planking embedded in the bed/sides of excavation will not be considered, nor the area supporting inclined struts in case of large pits/open excavation. All planks, boards, wallings, verticals, struts, props and all other materials required for shoring and subsequent safe dismantling and removal shall be included in the quoted unit rates.

3.16 Dewatering

The Contractor shall ensure that the excavation and the structures are free from water during construction and shall take all necessary precautions and measures to exclude ground/rain water so as to enable the works to be carried out in reasonably dry conditions in accordance with the construction programme. Sumps made for dewatering must be kept clear of the excavations/trenches required for further work. The method of pumping shall be approved by Engineer, but in any case, the pumping arrangement shall be such that there shall be no movement of subsoil or blowing in due to differential head of water during pumping. Pumping arrangements shall be adequate to ensure no delays in construction. The dewatering shall be continued for at least (7) seven days after the last pour of the concrete. The Contractor shall, however, ensure that no damage to the structure results on stopping of dewatering.

The Contractor shall study the sub-soil conditions carefully and shall conduct any tests necessary at the site with the approval of the Engineer to test the permeability and drainage conditions of the sub-soil for excavation, concreting etc., below ground level.

The scheme for dewatering and disposal of water shall be approved by the Engineer. The Contractor shall suitably divert the water obtained from dewatering from such areas of site where a buildup of water in the opinion of the Engineer obstructs the progress of the work,

leads to insanitary conditions by stagnation, retards the speed of construction and is detrimental to the safety of men, materials, structures and equipment.

When there is a continuous inflow of water and the quantum of water to be handled is considered in the opinion of Engineer, to be large, a well point system- single stage or multistage, shall be adopted. The Contractor shall submit to the Engineer, details of his well point system including the stages, the spacing, number and diameter of well points, headers etc., and the number, capacity and location of pumps for approval. Unless separately provided for in the Schedule of prices, the cost of dewatering shall be included in the item rate for excavation.

3.17 Measurement

Unless separately provided for in the Schedule of quantities, dewatering is deemed to have been included in the unit rates quoted for excavation. If separately provided for, the unit of measurement shall be as indicated in the Schedule of Quantities.

3.18 Rain Water Drainage

Grading in the vicinity of excavation shall be such as to exclude rain/ surface water draining into excavated areas. Excavation shall be kept clean of rain and such water as the Contractor may be using for his work by suitably pumping out the same. The scheme for pumping and discharge of such water shall be approved by the Engineer.

3.19 Earthen Embankment Construction

3.19.1 Scope

These Specifications shall apply to the construction of embankments including sub grades, earthen shoulders and miscellaneous backfills with approved materials obtained from roadway and drain excavation, borrow pits or other sources. All embankments, subgrade, earthen shoulders and miscellaneous backfills shall be constructed in accordance with the requirements of these Specifications and in conformity with the lines, grades, and cross-sections shown on the Drawings or as directed by the Engineer.

3.19.2 Physical Requirements of materials

The materials used in embankments, sub grades, earthen shoulders and miscellaneous backfills shall be soil, moorum, gravel, a mixture of those or any other material approved by the Engineer. Such materials shall be free of logs, stumps, roots, rubbish or any other ingredient likely to deteriorate or affect the stability of the embankment/subgrade.

The following types of material shall be considered unsuitable for embankment:

Materials from swamps, marshes and bogs.
Peat, log, stump and perishable material any soil that classifies as OL, OI, OH or Pt in accordance with IS: 1498.
Materials susceptible to spontaneous combustion.
Materials in frozen conditions.

Clay having liquid limit exceeding 70 and plasticity index exceeding 45 and
Materials with salts resulting in leaching in the embankment.

Expansive clay exhibiting marked swell and shrinkage properties ("free swelling index" exceeding 50 percent when tested as per IS: 2720 Part 40) shall not be used as a fill material. Where expansive clay with acceptable "free swelling index" value is used as a fill material, subgrade and top 500 mm portion of the embankment just below subgrade shall be non-expansive in nature.

Any fill material with a soluble sulphate content exceeding 1.9 grams of sulphate (expressed as SO3) per litre when tested in accordance with BS: 1377 Test 10, but using a 2:1 water-soil ratio shall not be deposited within 500 mm or other distance described in the Contract, of concrete, cement bound materials or other cementitious materials forming part of the Permanent Works.

Materials with a total sulphate content (expressed as SO3) exceeding 0.5 percent by mass, when tested in accordance with BS: 1377 Test 9 shall not be deposited within 500 mm, or other distances described in the Contract, of metallic items forming part of the Permanent Works.

The size of the coarse material in the mixture of earth shall ordinarily not exceed 75 mm when being placed in the embankment and 50 mm when placed in the subgrade. However, the Engineer may at his discretion permit the use of material coarser than this also if he is satisfied that the same will not present any difficulty as regards the placement of fill material and its compaction to the requirements of these Specifications. The maximum particle size shall not be more than two-thirds of the compacted layer thickness.

Ordinarily, only the materials satisfying the density requirements given in Table I shall be employed for the construction of the embankment and the subgrade.

Table-I. Density Requirements of Embankment and Subgrade Materials

Sr.	Type of Work	Maximum laboratory dry unit weight when tested as per IS: 2270 (Part 8)
1.	Embankments up to 3 meters height, not subjected to extensive flooding.	Not less than 15.2 kN/cum.
2.	Embankments exceeding 3 meters height or embankments of any height subject to long periods of inundation	Not less than 16.0 kN/cum.
3.	Sub grades and earthen shoulders / verges / backfill	Not less than 17.5 kN/cum.

Notes:

This Table is not applicable for lightweight fill material e.g. cinder, fly ash etc.

The Engineer may relax these requirements at his discretion taking into account the availability of materials for construction and other relevant factors.

The material to be used in subgrade should also satisfy design CBR at the dry unit weight applicable as per Table-II.

3.19.3 General requirements of materials

The materials for embankment shall be obtained from approved sources with preference given to materials becoming available from nearby roadway excavation or any other excavation under the same Contract.

The work shall be so planned and executed that the best available materials are saved for the subgrade and the embankment portion just below the subgrade.

Borrow Materials

Where the materials are to be obtained from designated borrow areas, the location, size and shape of these areas shall be as indicated by the Engineer and the same shall not be opened without his written permission. Where specific borrow areas are not designated by the Employer / the Engineer, arrangement for locating the source of supply of material for embankment and subgrade as well as compliance to environmental requirements in respect of excavation and borrow areas as stipulated, from time to time by the Ministry of Environment and Forests, Government of India and the local bodies, as applicable, shall be the sole responsibility of the Contractor.

Borrow pits along the road shall be discouraged. If permitted by the Engineer, these shall not be dug continuously. Ridges of not less than 8 m width should be left at intervals not exceeding 300 m. Small drains shall be cut through the ridges to facilitate drainage. The depth of the pits shall be so regulated that their bottom does not cut an imaginary line having a slope of 1 vertical to 4 horizontal projected from the edge of the final section of the bank, the maximum depth in any case being limited to 1.5 m. Also, no pit shall be dug within the offset width from the toe of the embankment required as per the consideration of stability with a minimum width of 10 m.
Haulage of material to embankments or other areas of fill shall proceed only when sufficient spreading and compaction plants is operating at the place of deposition.

No excavated acceptable material other than surplus to requirements of the Contract shall be removed from the site. Should the Contractor be permitted to remove acceptable material from the site to suit his operational procedure, then he shall make good any consequent deficit of material arising there from.

Where the excavation reveals a combination of acceptable and unacceptable materials, the Contractor shall, unless otherwise agreed by the Engineer, carry out the excavation in such a manner that the acceptable materials are excavated separately for use in the permanent works without contamination by the unacceptable materials. The acceptable materials shall be stockpiled separately.

The Contractor shall ensure that he does not adversely affect the stability of excavation or fills by the methods of stockpiling materials, use of plants or siting of temporary buildings or structures.

The Contractor shall obtain representative samples from each of the identified borrow areas and have these tested at the site laboratory following a testing programme approved by the

Engineer. It shall be ensured that the subgrade material when compacted to the density requirements as in Table II shall yield the design CBR value of the subgrade.

Table-II. Compaction Requirements for Embankment and Subgrade

Sr	Type of work/ material	Relative compaction as percentage of max. laboratory dry density as per IS: 2720 (Part 8)
1.	Subgrade and earthen shoulders	Not less than 97
2.	Embankment	Not less than 95
3.	Expansive Clays	
	a) Subgrade and 500 mm portion just below the subgrade	Not allowed
	b) Remaining portion of embankment	Not less than 90

The Contractor shall at least 7 working days before commencement of compaction submit the following to the Engineer for approval:

The values of maximum dry density and optimum moisture content obtained in accordance with IS: 2720 (Part 7) or (Part 8), as the case may be, appropriate for each of the fill materials he intends to use.
A graph of density plotted against moisture content from which each of the values in (1) above of maximum dry density and optimum moisture content were determined.
The Dry density-moisture content-CBR relationships for light, intermediate and heavy compactive efforts (light corresponding to IS: 2720 (Part 7), heavy corresponding to IS: 2720 (Part 8) and intermediate in-between the two) for each of the fill materials he intends to use in the subgrade.

Once the above information has been approved by the Engineer, it shall form the basis for compaction.

3.19.4 Construction Operations for Embankments

Setting out

After the site has been cleared to chapter-1, the work shall be set out. The limits of embankment/subgrade shall be marked by fixing batter pegs on both sides at regular intervals as guides before commencing the earthwork. The embankment / subgrade shall be built sufficiently wider than the design dimension so that surplus materials may be trimmed, ensuring that the remaining material is to the desired density and in position specified and conforms to the specified side slopes.

Dewatering

If the foundation of the embankment is in an area with stagnant water, and in the opinion of the Engineer it is feasible to remove it, the same shall be removed by bailing out or pumping, as directed by the Engineer and the area of the embankment foundation shall be kept dry. Care shall be taken to discharge the drained water so as not to cause damage to the works, crops or any other property. Due to any negligence on the part of the Contractor, if any such damage is

caused, it shall be the sole responsibility of the Contractor to repair / restore it to its original condition or compensate for the damage at its own cost. If the embankment is to be constructed under Water, Clause 3.19.5 shall apply.

Stripping and Storing topsoil

In localities where most of the available embankment materials are not conducive to plant growth, or when so directed by the Engineer, the topsoil from all areas of cutting and from all areas to be covered by embankment foundation shall be stripped to specified depths not exceeding 150 mm and stored in stockpiles of height not exceeding 2 m for covering embankment slopes, cut slopes and other disturbed areas where re-vegetation is desired. Topsoil shall not be unnecessarily trafficked either before stripping or when in a stockpile. Stockpiles shall not be surcharged or otherwise loaded and multiple handling shall be kept to a minimum.

Compacting ground supporting Embankment / Subgrade

When necessary, the original ground shall be leveled to facilitate placement of first layer of embankment, scarified, mixed with water and then compacted by rolling so as to achieve minimum dry density as given in Table-II.

In case where the difference between the subgrade level (top of the subgrade on which pavement rests) and ground level is less than 0.5 m and the ground does not have 97 percent relative compaction with respect to the dry density as given in Table-I, the ground shall be loosened up to a level 0.5 m below the subgrade level, watered and compacted in layers in accordance with Clause 3.19.4 to not less than 97 percent of dry density as given in Table-II.

Where so directed by the Engineer, any unsuitable material occurring in the embankment foundation shall be removed and replaced by approved materials laid in layers to the required degree of compaction.

Embankment or subgrade work shall not proceed until the foundations of embankments/subgrade have been inspected by the Engineer for satisfactory condition and approved.

Any foundation treatment specified for embankments especially high embankments, resting on suspect foundations as revealed by borehole logs shall be carried out in a manner and to the depth as desired by the Engineer. Where the ground on which embankment is to be built has any of the material types specified in Clause 3.19.2, at least 500 mm of such material must be removed and replaced by acceptable fill material before embankment construction commences.

Spreading material in layers and bringing to appropriate moisture content

The embankment and subgrade material shall be spread in layers of uniform thickness not exceeding 200 mm compacted thickness over the entire width of embankment by mechanical means, finished by a motor grader and compacted as per Clause 3.19.4. The motor grader blade shall have hydraulic control suitable for initial adjustment and maintain the same so as to achieve the specific slope and grade. Successive layers shall not be placed until the layer under

construction has been thoroughly compacted to the specified requirements as in Table-II and got approved by the Engineer. Each compacted layer shall be finished parallel to the final cross-section of the embankment.

Moisture content of the material shall be checked at the site of placement prior to commencement of compaction; if found to be out of agreed limits, the same shall be made good. Where water is required to be added in such construction, water shall be sprinkled from a water tanker fitted with sprinkler capable of applying water uniformly with a controllable rate of flow to variable widths of surfaces but without any flooding. The water shall be added uniformly and thoroughly mixed in soil by blading, discing or harrowing until and uniform moisture content is obtained throughout the depth of the layer.

If the material delivered to the roadbed is too wet, it shall be dried, by aeration and exposure to the sun, till the; moisture content is acceptable for compaction. Should circumstances arise, where owing to wet weather, the moisture content cannot be reduced to the required amount by the above procedure, compaction work shall be suspended.

Moisture content of each layer of soil shall be checked in accordance with IS: 2720 (Part 2), and unless otherwise mentioned, shall be so adjusted, making due allowance for evaporation losses, that at the time of compaction it is in the range of 1% above to 2% below the optimum moisture content determined in accordance with IS: 2720 (Part 7) or IS: 2720 (Part 8) as the case may be. Expansive clays shall, however, be compacted at moisture content corresponding to the specified dry density, but on the wet side of the optimum moisture content obtained from the laboratory compaction curve.

After adding the required amount of water, the soil shall be processed by means of graders, harrows, rotary mixers or as otherwise approved by the Engineer until the layer is uniformly wet.

Clods or hard lumps of earth shall be broken to have a maximum size of 75 mm when being placed in the embankment and a maximum size of 50 mm when being placed in the subgrade.

Embankment and other areas of fill shall, unless otherwise required in the Contract or permitted by the Engineer, be constructed evenly over their full width and their fullest possible extent and the Contractor shall control and direct construction plant and other vehicular traffic uniformly over them. Damage by construction plant and other vehicular traffic shall be made good by the Contractor with material having the same characteristics and strength as the material had before it was damaged.

Embankments and other areas of unsupported fills shall not be constructed with steeper side slopes, or to greater widths than those shown in the Contract, except to permit adequate compaction at the edges before trimming back, or to obtain the final profile following any settlement of the fill and the underlying material.

Whenever fill is to be deposited against the face of a natural slope, or sloping earthworks face including embankments, cuttings, other fills and excavations steeper than 1 vertical on 4 horizontal, such faces shall be benched as per Clause 3.19.5 immediately before placing the subsequent fill.

All permanent faces of side slopes of embankments and other areas of fill formed shall, subsequent to any trimming operations, be reworked and sealed to the satisfaction of the Engineer by tracking a tracked vehicle, considered suitable by the Engineer, on the slope or any other method approved by the Engineer.

Compaction

Only the compaction equipment approved by the Engineer shall be employed to compact the different material types encountered during construction. Smooth wheeled, vibratory, pneumatic tyred, sheepfoot or pad foot rollers, etc., of suitable size and capacity as approved by the Engineer shall be used for the different types and grades of materials required to be compacted either individually or in suitable combinations.

The compaction shall be done with the help of vibratory roller of 80 to 100 kN static weight with plain or pad foot drum or heavy pneumatic tyred roller of adequate capacity capable of achieving required compaction.

The Contractor shall demonstrate the efficiency of the equipment he intends to use by carrying out compaction trials. The procedure to be adopted for these site trials shall first be submitted to the Engineer for approval.

Earthmoving plant shall not be accepted as compaction equipment nor shall the use of a lighter category of plant to provide any preliminary compaction to assist the use of heavier plant be taken into account.

Each layer of the material shall be thoroughly compacted to the densities specified in Table-I. Subsequent layers shall be placed only after the finished layer has been tested according to Clause 903.2.2 of MORTH Specifications for Roads and Bridge Works (V Revision) and accepted by the Engineer. The Engineer may permit measurement of field dry density by a nuclear moisture / density gauge used in accordance with agreed procedure and the gauge is calibrated to provide results identified to that obtained from tests in accordance with IS: 2720 (Part 28). A record of the same shall be maintained by the Contractor.

When density measurements reveal any soft areas in the embankment / subgrade / earthen shoulders, further compaction shall be carried out as directed by the Engineer. If inspite of that the specified compaction is not achieved, the material in the soft areas shall be removed and replaced by approved material, compacted to the density requirements and satisfaction of the Engineer.

Drainage

The surface of the embankment / subgrade at all times during construction shall be maintained at such a cross fall (not flatter than that required for effective drainage of an earthen surface) as will shed water and prevent ponding.

Repairing of damages caused by rain / spillage of water

The soil in the affected portion shall be removed in such areas as directed by the Engineer before next layer is laid and refilled in layers and compacted using appropriate mechanical means such as small vibratory roller, plate compactor or power rammer to achieve the required density in accordance with Clause 3.19.5. If the cut is not sufficiently wide for use of required mechanical means for compaction, the same shall be widened suitably to permit their use for proper compaction. Tests shall be carried out as directed by the Engineer to ascertain the density requirements of the repaired area. The work of repairing the damages including widening of the cut, if any, shall be carried out by the Contractor at his own cost, including the arranging of machinery / equipment for the purpose.

Finishing operations

Finishing operations shall include the work of shaping and dressing the shoulders / verge / roadbed and side slopes to conform to the alignment, levels, cross-sections and dimensions shown on the Drawings or as directed by the Engineer subject to the surface tolerance described in **Clause 902** of MORTH Specifications for Roads and Bridge Works (V Revision). Both the upper and lower ends of the side slopes shall be rounded off to improve appearance and to merge the embankment with the adjacent terrain.

The topsoil, removed and conserved earlier shall be spread over the fill slopes as per directions of the Engineer to facilitate the growth of vegetation. Slopes shall be roughened and moistened slightly prior to the application of the topsoil in order to provide satisfactory bond. The depth of the topsoil shall be sufficient to sustain plant growth, the usual thickness being from 75 mm to 150 mm.

Where directed, the slopes shall be turfed with sods in accordance with **Clause 3.20**. If seeding and mulching of slopes is prescribed, this shall be done to the requirement of **Clause 3.21**.

When earthwork operations have been substantially completed, the road area shall be cleared of all debris, and ugly scars in the construction area responsible for objectionable appearance eliminated.

3.19.5 Construction of Embankment and Subgrade under Special Conditions

Earthwork for widening existing road embankment

When an existing embankment and / or subgrade is to be widened and its slope are steeper than 1 vertical on 4 horizontal, continuous horizontal benches, each at least 300 mm wide, shall be cut into the old slope for ensuring adequate bond with the fresh embankment / subgrade material to be added. The material obtained from cutting of benches could be utilized in the widening of the embankment / subgrade. However, when the existing slope against which the fresh material is to be placed is flatter than 1 vertical on 4 horizontal, the slope surface may only be ploughed or scarified instead of resorting to benching.

Where the width of the widened portions is insufficient to permit the use of conventional rollers, compaction shall be carried out with the help of small vibratory rollers / plate compactors / power rammers of any other appropriate equipment approved by the Engineer.

End dumping of material from trucks for widening operations shall be avoided except in difficult circumstances when the extra width is too narrow to permit the movement of any other types of hauling equipment.

Earthwork for embankment and subgrade to be placed against sloping ground:

Where an embankment / subgrade is to be placed against sloping ground, the latter shall be appropriately benched or ploughed / scarified as required in **Clause 3.19.5** before placing the embankment / subgrade material. Extra earthwork involved in benching or due to ploughing / scarifying etc. shall be considered incidental to the work.

For wet conditions, benches with slightly inward fall subsoil drains at the lowest point shall be provided as per the Drawings, before the fill is placed against sloping ground.

Earthwork over existing road surface:

Where the embankment is to be placed over an existing road surface, the work shall be carried out as indicated below:

If the existing road surface is of granular or bituminous type and lies within 1 m of the new subgrade level, the same shall be scarified to a depth of 50 mm or more if specified, so as to provide ample bond between the old and new material ensuring that at least 500 mm portion below the top of new subgrade level is compacted to the desired density.

If the existing road surface is of cement concrete type and lies within 1 m of the new subgrade level the same shall be removed completely.

If the level difference between the existing road surface and the new formation level is more than 1 m, the existing surface shall be permitted to stay in place without any modification.

Embankment and subgrade around structures:

To avoid interference with the construction of abutments, wing walls or return walls of culvert / bridge structures, the Contractor shall, at points to be determined by the Engineer suspend work on embankment forming approaches to such structures, until such time as the construction of the latter is sufficiently advanced to permit the completion of approaches without the risk of damage to the structure.

Unless directed otherwise, the filling around culverts, bridges and other structures up to a distance of twice the height of the road from the back of the abutment shall be carried out independent of the work on the main embankment. The fill material shall not be placed against any abutment or wing wall, unless permission has been given by the Engineer but in any case not until the concrete or masonry has been in position for 14 days.

The embankment and subgrade shall be brought up simultaneously in equal layers on each side of the structure to avoid displacement in equal layers on each side of the structure to avoid displacement and unequal pressure. The sequence of work in this regard shall be got approved from the Engineer.

The material used for backfill shall not be an organic soil or highly plastic clay having plasticity index and liquid limit more than 20 and 40 respectively when tested according to IS: 2720 (Part 5). Filling behind abutments and wing walls for all structures shall conform to the general guidelines given in Appendix 6 of IRC:78 (Standard Specifications and Code of Practice for Road Bridges-Section VII) in respect of the type of material, the extent of backfill, its laying and compaction etc. The fill material shall be deposited in horizontal layers in loose thickness and compacted thoroughly to the requirements of **Table-II.**

Where the provision of any filter medium is specified behind the abutment, the same shall be laid in layers simultaneously with the laying of fill material. The material used for filter shall conform to the requirements for filter medium spelt out in **Clause 2502** of MORTH Specifications for Roads and Bridge Works (V Revision) unless otherwise specified in the Contract.

Where it may be impracticable to use conventional rollers, the compaction shall be carried out by appropriate mechanical means such as small vibratory roller, plate compactor or power rammer. Care shall be taken to see that the compaction equipment does not hit or come too close to any structural member so as to cause any damage to them or excessive pressure against the structure.

Construction of Embankment over Ground Incapable of Supporting Construction Equipment:

Where embankment is to be constructed across ground which will not support the weight of repeated heavy loads of construction equipment, the first layer of the fill may be constructed by placing successive loads of material in a uniformly distributed layer of a minimum thickness required to support the construction equipment as permitted by the Engineer. The Contractor, if so desired by him, may also use suitable geosynthetic material to increase the bearing capacity of the foundation. This exception to normal procedure will not be permitted where, in the opinion of the Engineer, the embankments could be constructed in the approved manner over such ground by the use of lighter or modified equipment after proper ditching and drainage have been provided. Where this exception is permitted, the selection of the material and the construction procedure to obtain an acceptable layer shall be the responsibility of the Contractor. The cost of providing suitable traffic conditions for construction equipment over any area of the Contract will be the responsibility of the Contractor and no extra payment will be made to him. The remainder of the embankment shall be constructed as specified in Clause 3.19.4.

Embankment construction under water

Where filling or backfilling is to be placed under water, only acceptable granular material or rock shall be used unless otherwise approved by the Engineer. Acceptable granular material shall consist of graded, hard durable particles with maximum particle size not exceeding 75 mm. The material should be non-plastic having uniformity coefficient of not less than 10. The material placed in open water shall be deposited by end tipping without compaction.

Earthwork for high embankment

In the case of high embankments, the Contractor shall normally use the material from the specified borrow area. In case he desires to use different material for his own convenience, he shall have to carry out necessary soil investigations and redesign the high embankment at his own cost. The Contractor shall then furnish the soil test data and design of high embankment for approval of the Engineer, who reserve the right to accept or reject it.

If necessary, stage construction of fills and any controlled rates of filling shall be carried out in accordance with the Contract including installation of instruments and its monitoring.

Where required, the Contractor shall surcharge embankments or other areas of fill with approved material for the periods specified in the Contract. If settlement of surcharged fill results in any surcharging material, which is unacceptable for use in the fill being surcharged, lying below formation level, the Contractor shall remove the unacceptable material and dispose it as per direction of the Engineer. He shall then bring the resultant level up to formation level with acceptable material.

Settlement period

Where settlement period is specified in the Contract, the embankment shall remain in place for the required settlement period before excavating for abutment, wingwall, retaining wall, footings, etc., or driving foundation piles. The duration of the required settlement period at each location shall be as provided for in the Contract or as directed by the Engineer.

3.19.6 Plying of Traffic

Construction and other vehicular traffic shall not use the prepared surface of the embankment and / or subgrade without the prior permission of the Engineer. Any damage arising out of such use shall, however, be made good by the Contractor at his own expense as directed by the Engineer.

3.19.7 Surface Finish and Quality Control of Work

The surface finish of construction of subgrade shall conform to the requirements of Clause 902 of MORTH Specifications for Roads and Bridge Works (V Revision). Control on the quality of materials and works shall be exercised in accordance with Clause 903 of MORTH Specifications for Roads and Bridge Works (V Revision).

3.19.8 Subgrade Strength

It shall be ensured prior to actual execution that the borrow area material to be used in the subgrade satisfies the requirements of design CBR.

Subgrade shall be compacted and finished to the design strength consistent with other physical requirements. The actual laboratory CBR values of constructed subgrade shall be determined on undisturbed samples cut out from the compacted subgrade in CBR mould fitted with

cutting shoe or on remoulded samples, compacted to the field density at the field moisture content.

3.19.9 Measurements for Payment

Earth embankment/subgrade construction shall be measured separately by taking cross sections at intervals in the original position before the work starts and after its completion and computing the volumes of earthwork in cubic metres by the method of average end areas.

The measurement of fill material from borrow areas shall be the difference between the net quantities of compacted fill and the net quantities of suitable material brought from roadway and drainage excavation. For this purpose, it shall be assumed that one cum. of suitable material brought to site from road and drainage excavation forms one cum. of compared fill and all bulking or shrinkage shall be ignored.

Construction of embankment under water shall be measured in cum.

Construction of high embankment with specified material and in specified manner shall be measured in cum.

Stripping including storing and reapplication of topsoil shall be measured in cum.

Work involving loosening and recompacting of ground supporting embankment / subgrade shall be measured in cum.

Removal of unsuitable material at embankment / subgrade foundation and replacement with suitable material shall be measured in cum.

Scarifying existing granular / bituminous road surface shall be measured in square metres.

Dismantling and removal of existing cement concrete pavement shall measured vide Clause 202.6 of MORTH Specifications for Roads and Bridge Works (V Revision).

Filter medium and backfill material behind abutments, wing walls and other retaining structures shall be measured as finished work in position in cum.

3.19.10 Rates

The Contract unit rates for the items of embankment and subgrade construction shall be payment in full for carrying out the required operations including full compensation for:

Cost of arrangement of land as a source of supply of material of required quantity for construction unless provided otherwise in the Contract;

Setting out;

Compacting ground supporting embankment / subgrade except where removal and replacement of unsuitable material or loosening and recompacting is involvedScarifying or

cutting continuous horizontal benches 300 mm wide on side slopes of existing embankment and subgrade as applicable.Cost of watering or drying of material in borrow areas and / or embankment and subgrade during construction as required.

Spreading in layers bringing to appropriate moisture content and compacting to Specification requirements. Shaping and dressing top and slopes of the embankment and subgrade including rounding of corners. Restricted working at sites of structures, Working on narrow width of embankment and subgrade.

Excavation in all soils from borrow pits / designated borrow areas including clearing and grubbing and transporting the material to embankment and subgrade site with all lifts and leads unless otherwise provided for in the Contract;

All labour, materials, tools, equipment and incidentals necessary to complete the work to the Specifications, Dewatering and Keeping the embankment / completed formation free of water. In case the Contract unit rate specified is not inclusive of all leads, the unit rate for transporting material beyond the initial lead, as specified in the Contract for construction of embankment and subgrade shall be inclusive of full compensation for all labour, equipment, tools and incidentals necessary on account of the additional haul or transportation involved beyond the specified initial lead.

The Contract unit rate for the items of stripping and storing topsoil and of reapplication of topsoil shall include full compensation for all the necessary operations including all lifts, but leads up to 1000 m.

The Contract unit rate for loosening and recompacting the loosened materials at subgrade shall include full compensation for loosening to the specified depth, including breaking clods, spreading in layers, watering where necessary and compacting to the requirements.

The Contract unit rate for scarifying existing granular / bituminous road surface shall be payment in full for carrying out the required operations including full compensation for all labour, materials, tools, equipment and incidentals necessary to complete the work. This will also comprise of handling, salvaging, stacking and disposing of the dismantled materials within all lifts and up to a lead of 1000 m or as otherwise specified.

Clause 202.7 of MORTH Specifications for Roads and Bridge Works (V Revision) shall apply as regards Contract unit rate for dismantling and removal of existing cement concrete pavement.

The Contract unit rate for providing and laying filters material behind abutments shall be payment in full for carrying out the required operations including all materials, labour, tools, equipment and incidentals to complete the work to Specifications.
Clause 3.19.5 shall apply as regards Contract unit rate for construction of embankment under water.

Clause 3.19.5 shall apply as regards Contract unit rate for construction of high embankment. It shall include cost of instrumentation, its monitoring and settlement period, where specified in the Contract or directed by the Engineer.

3.20 Soil Erosion and Sedimentation Control

3.20.1 Scope

This work shall consist of measures as shown on plans or as directed by the Engineer to control soil erosion, sedimentation and water pollution, through use of berms, dikes, sediment basins, fibre mats, mulches, grasses, slope drains, and other devices.

3.20.2 Materials

All materials shall meet commercial grade standards and shall be approved by the Engineer before being used in the work.

3.20.3 Construction Operations

Prior to the start of the relevant construction, the Contractor shall submit to the Engineer for approval his schedules for carrying out temporary and permanent erosion / sedimentation control works as are applicable for the items of clearing and grubbing, roadway and drainage excavation, embankment / subgrade construction, bridges and other structures across water course, pavement courses and shoulders. He shall also submit for approval his proposed method of erosion / sedimentation control on service road and borrowpits and his plan for disposal of waste materials. Work shall not be started until the erosion / sedimentation control schedules and methods of operations for the applicable construction have been approved by the Engineer.

The surface area of erodible earth material exposed by clearing and grubbing, excavation, borrow and fill operations shall be limited to the extent practicable. The Contractor may be directed to provide immediate permanent or temporary erosion and sedimentation control measures to prevent soil erosion and sedimentation that will adversely affect construction operations, damage adjacent properties, or cause contamination of nearby streams or other water courses, lakes, reservoirs etc. Such work may involve the construction of temporary berms, dikes, sediment basins, slope drains and use of temporary mulches, fabrics, mats, seeding, or other control devices or methods as necessary to control erosion and sedimentation. Cut and fill slopes shall be seeded and turfed as required on the plans.

The Contractor shall be required to incorporated all permanent erosion and sedimentation control features into the project at the earliest practicable time as outlined in his accepted schedule to minimize the need for temporary erosion and sedimentation control measures.

Temporary erosion / sedimentation and pollution control measures will be used to control the phenomenon of erosion, sedimentation, and pollution that may develop during normal construction practices, but may neither be foreseen during the design stage nor associated with permanent control features on the Project.

Where erosion or sedimentation is likely to be a problem, clearing and grubbing operations should be so scheduled and performed that grading operations and permanent erosion or sedimentation control features can follow immediately thereafter if the project conditions permit; otherwise, temporary erosion or sedimentation control measures may be required

between successive construction stages. Under no conditions shall a large surface area of erodible earth material be exposed at one time by clearing and grubbing or excavation without prior approval of the Engineer.

The Engineer may limit the area of excavation, borrow and embankment operations in progress, commensurate with the Contractor's capability and progress in keeping the finish grading, mulching, seeding and other such permanent erosion, sedimentation and pollution control measures, in accordance with the accepted schedule. Should seasonal limitations make such coordination unrealistic, temporary erosion / sedimentation control measures shall be taken immediately to the extent feasible and justified.

In the event temporary erosion, sedimentation and pollution control measures become necessary due to the Contractor's negligence, carelessness or failure to install permanent controls as a part of the work as scheduled or ordered by the Engineer, these shall be carried out at the Contractor's own expense. Temporary erosion, sedimentation and pollution control work required, which is not attributed to the Contractor's negligence, carelessness of failure to install permanent controls, will be performed as ordered by the Engineer.

Temporary erosion, sedimentation and pollution control may include construction work outside the right-of-way where such work is necessary as result of road construction such as borrow pit operations, service roads and equipment storage sites.

The temporary erosion, sedimentation and pollution control features installed by the Contractor shall be acceptably maintained by him till these are needed, unless otherwise agreed by the Engineer.

3.20.4 Measurements for Payment

The soil erosion, sedimentation and pollution control works will be measured in terms of units specified in the Bill of Quantities for the respective items.

3.20.5 Rates

The contract unit rate for different items of soil erosion, sedimentation and pollution control works shall be payment in full for carrying out all required operations including full compensation for all labour, tools, equipment and incidents to complete the works to the Specifications.

3.21 Turfing with Sods

3.21.1 Scope

This work shall consist of furnishing and laying of the live sod of perennial turf forming grass on embankment slopes, verges (earthen shoulders) or other locations as directed by the Engineer. Unless otherwise specified, the work shall be taken up as soon as possible following construction of the embankment, provided the season is favorable for establishment of the sod.

3.21.2 Materials

The sod shall consist of dense, well-rooted growth of permanent and desirable grasses, indigenous to the locality where it is to be use, and shall be practically free from weeds or other undesirable matter. At the time the sod is cut, the grass on the sod shall have a length of approximately 50 mm and the sod shall have freed of debris.

Thickness of the sod shall be as uniform as possible, with some 50-80 mm or so of soil covering the grass roots depending on the nature of the sod, so that practically all the dense root system of the grasses is retained in the sod strip. The sods shall be cut in rectangular strips of uniform width, not less than about 250 mm X 300 mm in size but not so large that it is inconvenient to handle and transport these without damage. During wet weather, the sod shall be allowed to dry sufficiently to prevent rearing during handling and during dry weather shall be watered before lifting to ensure its vitality and prevent the dropping of the soil in handling.

3.21.3 Construction Operations for Turfing with Sods

Preparation of earth bed

The area to be sodded shall have been previously constructed to the required slope and cross section. Soil on the area shall be loosened, freed of all stones larger than 50 mm size, sticks, stumps and any undesirable foreign matter, and brought to a reasonably fine granular texture to a depth of not less than 25 mm for receiving the sod.

Where required, topsoil shall be spread over the slopes. Prior to placing the topsoil, the slopes shall be scarified to a depth which, after settlement, will provide the required nominal depth shown on the plans. Spreading shall not be done when the ground is excessively wet.

Following soil preparation and top soiling, where required, fertilizer and ground limestone when specified shall be spread uniformly at the rate indicated on the plans. After spreading, the materials are incorporated in the soil by discing or other means to the depths shown on the plans.

Placing the sods

The prepared sod bed shall be moistened to the loosened depth, if not already sufficiently moist, and the sod shall be placed thereon within approximately 24 hours after the same had been cut. Each sod strip shall be laid edge to edge and such that the joints caused by abutting ends are staggered. Every strip, after it is snugly placed against the strips already in position, shall be lightly tamped with suitable wooden or metal tampers so as to eliminate air pockets and to press it into the underlying soil.

On side slopes steeper than 2 (horizontal) to 1 (vertical), the laying of sods shall be started from bottom upwards. At points where water may flow over a sodded area, the upper edges of the sod strips shall be turned into the soil below the adjacent area and a layer of earth placed over this followed by its through compaction.

Staking the sods

Where the side slope is 2 (horizontal) to 1 (vertical) or steeper and the distance along the slope is more than 2 m, the sods shall be staked with pegs or nails spaced approximately 500 to 1000 mm along the longitudinal axis of the sod strips. Stakes shall be driven approximately plumb through the sods to be almost flush with them.

Top dressing

After the sods have been laid in position, the surface shall be cleaned of loose sod, excess soil and other foreign material. Thereafter, a thin layer of topsoil shall be scattered over the surface of top dressing and the area thoroughly moistened by sprinkling with water.

Watering and maintenance

The sods shall be watered by the Contractor for a period of at least four weeks after laying. Watering shall be so done as to avoid erosion and prevent damage to sodded areas by wheels of water tanks.

The Contractor shall erect necessary warning signs and barriers, repair or replace sodded areas failing to show uniform growth of grass or damaged by his operations and shall otherwise maintain the sod at his cost until final acceptance.

Measurement for Payment

Turfing with sods shall be measured as finished work in square metres.

Rate

The Contract unit rate for turfing with sods shall mean payment in full for carrying out all the required operations explained above including compensation for:

Furnishing all the materials to be incorporated in the Works with all leads and lifts; and
All labour, tools, equipment and incidental to complete the work in accordance with these Specifications.

3.22 Seeding and Mulching

3.22.1 Scope

This shall consist of preparing slopes, placing topsoil, furnishing all seeds, commercial or organic fertilizers and mulching materials, providing jute netting and placing and incorporation the same on embankment slopes or other locations designated by the Engineer or shown in the Contract documents.

3.22.2 Materials

Seeds

The seeds shall be approved quality and type suitable for the soil on which these are to be

applied and shall have acceptable purity and germination to requirements set down by the Engineer.

Fertilizer

This shall consist of standard commercial materials and conform to the grade specified. Organic manure shall be fully purified organic matter such as cow dung.

Mulching materials

This shall consist of straw, hay wood shavings or sawdust and shall be delivered dry. They shall be reasonably free of weed seed and such foreign materials as may detract from their effectiveness as mulch or be injurious to the plant growth.

Topsoil

Topsoil shall not be obtained from an area known to have noxious weeds growing in it. If treated with herbicides or sterilents, it shall be got tested by appropriate agricultural authority to determine the residual in the soil. Topsoil shall contain less than 2 per cent and more than 12 per cent organic matter.

Bituminous Emulsion

A suitable grade of bituminous cutback or emulsion used as a tie down for mulch shall be as described in the Contract document or as desired by the Engineer. Emulsified bitumen shall not contain any solvent or diluting agent toxic to plant life.

Netting

Jute netting shall be undyed jute yam woven into a uniform open weave with approximate 2.5 cm square openings. Geonetting shall be made of uniformly extruded rectangular mesh having mesh opening of 2 cm x 2 cm. The colour may be black or green. It shall weigh not less than 3.8 kg per 1000 sq. m.

3.22.3 Seeding Operations

Seed-bed Preparation

The area to be seeded shall be brought to the required slope and cross-section by filling, reshaping eroded areas and refinishing slopes, median etc. Topsoil shall be evenly spread over the specified areas to the depth shown on the plans, unless otherwise approved by the Engineer. The see-bed preparation shall consist of eliminating all live plants by suitable means using agricultural implements. All stones 150 mm in smallest dimension and larger shall be removed.

The soil shall be excavated on the contour to a depth of 100 mm. All clods large than 25 mm in diameter shall be crushed and packed. Where necessary, water shall then be applied. All topsoil shall be compacted unless otherwise specified or approved by the Engineer.

Compaction shall be by slope compactor, cleated tractor or similar equipment approved by the Engineer. Equipment shall be so designed and constructed as to produce a uniform rough textured surface ready for seeding and mulching and which will bond the topsoil to the underlying material. The entire area shall be covered by a minimum of 4 passes or 2 round trips of the roller or approved equipment.

Fertilizer application

Fertilizer to the required quantities shall be spread and thoroughly incorporated into the soil surface as a part of the seed-bed preparation.

Planting of seeds

All seeds shall be planted uniformly at the approved rate. Immediately after sowing, the area shall be raked, dragged or otherwise treated so as to cover the seeds to a depth of 6 mm. The operation of seed sowing shall not be performed when the ground is muddy or when the soil or weather conditions would otherwise prevent proper soil preparation and subsequent operations.

Soil Moisture and Watering requirements

Soil moisture shall exist throughout the zone from 25 mm to at least 125 mm below the surface at the time of planting. Watering off the seeded areas shall be carried out as determined by the Engineer.

Mulching, Applying Bituminous Emulsion and Jute Netting / Geonetting

Within 24 hours of seeding, mulching material mixed with organic manure shall be placed so as to form a continuous, unbroken cover of approximate uniform thickness of 25 mm using an acceptable mechanical blower. Mulching material shall be held in place and made resistant to being blown away by suitable means approved by the Engineer. When called for in the Contract documents, mulch material shall be anchored in place with bituminous emulsion applied at the rate of 2300 liters per hectare.

Any mulch disturbed or displaced following application shall be removed, reseeded and remulched as specified. Jute netting / Geonetting shall be unrolled and placed parallel to the flow of water immediately following the bringing, to finished grade, the area specified on the plans or the placing of seed and fertilizer. Where more than one strip is required to cover the given areas, they shall overlap a minimum of 100 mm. Jute netting / Geonetting shall be held in place by approved wire staples, pins, spikes or wooden stakes driven vertically into the soil

Maintenance

The Contractor shall maintain all seeded and mulched areas until final acceptance. Maintenance shall include protection of traffic by approved warning signs or barricades and

repairing any areas damaged following the seeding and mulching operations. If mulched areas become damaged, the area shall be reshaped and then seeded and mulched again as originally specified.

Measurement for payment

Seeding and mulching shall be measured as finished work in square metres.

Rate

The Contract unit rate for seeding and mulching shall be payment in full for carrying out all the required operations including full compensation for all materials, labour, tools and incidentals.

Preparation and Surface Treatment of Formation

Preparation and surface treatment of the formation, that is top of the subgrade, shall be carried out only after completion of any specified subgrade drainage and unless otherwise agreed by the Engineer, immediately prior to laying the sub-base or the road base where no sub-base is required. The sequence of operations shall be as follows:

All surfaces below carriageway, lay byes, footways and hard shoulders shall, after reinstatement of any soft areas to the required Specifications be well cleaned and freed of mud and slurry.

The surface shall be compacted by 4 passes of a smooth wheeled roller of 80 to 100 kN weight after spraying requisite amount of water, if required, before the commencement of rolling.

The formation shall, wherever necessary, be regulated and trimmed to the requirements with motor grader.

The trimmed formation shall be rolled by one pass of smooth wheeled roller of 80 to 100 kN weight after spraying requisite amount of water, if required, before the commencement of rolling.

Where the completed formation is not immediately covered with sub base or road base material, its moisture content shall be maintained to prevent cracking in the formation by suitable measures as approved by the Engineer. The entire work of surface treatment of formation shall be deemed as incidental to the work of sub-base / base course to be provided on the subgrade and as such no extra payment shall be made for the same.

Works to be Kept Free of Water

The Contractor shall arrange for the rapid dispersal of water collected / accumulated on the earthwork or completed formation during construction or on the existing roadway or which enters the earthwork or any other item of work from any source, and where practicable, the

water shall be discharged into the permanent outfall of the drainage system. The arrangement shall be made in respect of all earthwork including excavation for pipe trenches, foundations or cuttings.

The Contractor shall provide, where necessary, temporary water courses, ditches, drains, pumping or other means for maintaining the earthwork free from water. Such provisions shall include carrying out the work of forming the cut sections and embankments in such manner that their surfaces have at all times a sufficient minimum crossfall and, where practicable, a sufficient longitudinal gradient to enable them to shed water and prevent ponding.

The works involved in keeping the earthwork or any other item of works free of water shall be deemed as incidental to the respective item of work and as such no separate payment shall be made for the same.

3.23 Gabion Embankment

Gabions are compartmented rectangular containers made of heavily galvanised steel wire, filled with stones, the gabion becomes a large, flexible and permeable building block. Gabions comprises of welded wire mesh panels accurately cut to size with heavy section wire spirals used for interconnecting the edges. The meshes and spirals are pre galvanized with zinc coating of 450 gram per m2. Gabion shall be confirming to ASTM-A974 (Standard Specifications for Welded Wire Fabric Gabions and Gabion Mattresses).

Welded wire mesh is a prefabricated reinforcement consisting of a series of parallel longitudinal wires with accurate spacing welded to cross wires at the required spacing. The welding of the wires is achieved by electric resistance welding with solid state electronic control and all the spacing are controlled by the automatic mechanism of high reliability. There is no foreign metal added at the joint.

The intersecting wires are actually fused into a homogeneous section thereby ensuring permanency of spacing and alignment in either direction. Welded Mesh shall be as per IS:4948 (latest Version). Gabions shall be fabricated in such a manner that the sides, ends, lids and diaphragms can be assembled at the construction site into a rectangular basket of the specified sizes. The basket shall be a single unit construction. In other words, the base, lid and sides shall be woven into a single unit. The ends and diaphragms shall be connected to the base section of the gabion. This connection should be such that strength and flexibility at the point of intersection is at least equal to that of the mesh. Gabion shall be provided minimum 0.5m below ground level.

The boulders shall be hard and shall not deteriorate under water. The section shall be worked out considering 10% porosity with a depth of 1m below the ground to a top level. The slope can be upto 1:0.25. boulder size shall not exceed 200mm.

3.24 Site Filling

3.24.1 Sand fill

Sandy fill shall be deposited to bring the grade level to the desired elevation after compaction of fill. Sandy fill shall be carried out in one of the following methods as detailed in the drawings:

Compaction of sandy fill by flooding the area shall be carried out where so specified. In this case, Contractor should ensure that the fill material is not washed away. This work shall be carried out as directed by Engineer.

Sandy fill shall be compacted where so specified by 12 tonne vibrating rollers. The fill material shall be compacted to the required density.

If the density of fill or use of rollers for compaction is not specified, Contractor shall ensure necessary compaction by the passage of trucks, carrying the fill material over the deposited fill in such a way that the entire fill area is covered. This will reasonably compact the sand fill and will be accepted by Engineer. However, Contractor shall ensure that every layer is thus compacted before the succeeding layers are deposited. Each layer shall not exceed 200mm in thickness.

3.24.2 Soil fill

Approved soil fill consisting of ordinary soil, murrum, soil containing gravel, shingle, etc. shall be deposited in layers not exceeding 200mm. Contractor should ensure that all clods of earth are broken down to a size not larger than 100mm.

Where density of fill or use of rollers is not specified, the fill shall be carried out as specified above.

Where specified, the required density to fill shall be obtained by proper compaction.

3.24.3 Measurement

Measurement shall be made on the basis of Clause 3.13.

End of Chapter-3

CHAPTER – 4

CONCRETE AND ALLIED WORKS

CHAPTER - 4

CONCRETE AND ALLIED WORKS

4.1 Applicable Codes

4.1.1 Materials

1) IS: 269 Specification for Ordinary Portland cement.
2) IS: 455 Specification for Portland slag cement.
3) IS: 1489 Specification for Portland-pozzolana cement (Part 1&2).
4) IS: 12330 Specification for sulphate resisting Portland cement.
5) IS: 383 Specification for coarse and fine aggregates from natural sources for concrete.
6) IS: 432 Specification for mild steel and medium (tensile steel bars and hard-drawn steel) wires for concrete reinforcement. (Part 1 and 2)
7) IS: 1786 Specification for high strength deformed steel bars and wires for concrete reinforcement.
8) IS: 1566 Specification for hard-drawn steel wire fabric for concrete reinforcement.
9) IS: 9103 Specification for admixtures for concrete.
10) IS: 2645 Specification for integral cement water- proofing compounds.
11) IS: 4990 Specification for plywood for concrete shuttering work.

4.1.2 Material Testing

1) IS: 650 Specification for standard sand for testing of cement
2) IS: 2430 Methods for sampling of aggregates for concrete.
3) IS.2386 Methods of test for aggregates for concrete (Parts 1 to 8)
4) IS: 3025 Methods of sampling and test (physical and chemical) for water used in industry.
5) IS.4031 Methods of physical tests for hydraulic cement (Parts 1 to 15)
6) IS: 4032 Method chemical analysis of hydraulic cement.
7) IS: 6925 Methods of test for determination of water soluble chlorides in concrete admixtures.

4.1.3 Material Storage

1) IS: 4082 Recommendations on stacking and storing of construction materials at site.

4.1.4 Concrete Mix Design

1) IS: 10262 Recommended guidelines for concrete mix design.
2) SP: 23 (S&T) Handbook on Concrete Mixes.

4.1.5 Concrete Testing

1) IS: 1199 Method of sampling and analysis of concrete.
2) IS: 516 Method of test for strength of concrete.
3) IS: 9013 Method of making, curing and determining compressive strength of accelerated cured concrete test specimens.
4) IS: 8142 Method of test for determining setting time of concrete by penetration resistance.
5) IS: 9284 Method of test for abrasion resistance of concrete.
6) IS: 2770 Methods of testing bond in reinforced concrete.

4.1.6 Equipments

1) IS: 1791 Specification for batch type concrete mixers.
2) IS: 2438 Specification for roller pan mixer.
3) IS: 4925 Specification for concrete batching and mixing plant.
4) IS: 5892 Specification for concrete transit mixer and agitator.
5) IS: 7242 Specification for concrete spreaders.
6) IS: 2505 General Requirements for concrete vibrators: Immersion type.
7) IS: 2506 General Requirements for screed board concrete vibrators.
8) IS: 2514 Specification for concrete vibrating tables.
9) IS: 3366 Specification for pan vibrators.
10) IS: 4656 Specification for form vibrators for concrete.
11) IS: 11993 Code of practice for use of screed board concrete vibrators.
12) IS: 7251 Specification for concrete finishers.
13) IS: 2722 Specification for portable swing weigh batchers for concrete (single and double bucket type).
14) IS: 2750 S Specification for steel scaffoldings.

4.1.7 Codes of Practice

1) IS: 456 Code of practice for plain and reinforced concrete.
2) IS: 457 Code of practice for general construction of plain and reinforced concrete for dams and other massive structures.
3) IS: 3370 Code of practice for concrete structures for storage of liquids (Parts 1 to 4)
4) IS: 3935 Code of practice for composite construction.
5) IS: 2204 Code of practice for construction of reinforced concrete shell roof.
6) IS: 2210 Criteria for the design of reinforced concrete shell structures and folded plates.
7) IS: 2502 Code of practice for bending and fixing of bars for concrete reinforcement.
8) IS: 5525 Recommendation for detailing of reinforcement in reinforced concrete works.
9) IS: 2911 Code of practice for Design and construction of Pile foundations. (Part 1 to 4)
10) IS: 9417 Specification for welding cold worked bars for reinforced concrete construction.
11) IS: 3558 Code of practice for use of immersion vibrators for consolidating concrete.
12) IS: 3414 Code of practice for design and installation of joints in buildings.
13) IS: 4326 Code of practice for earthquake resistant design and construction of building.
14) IS: 4014 Code of practice for steel tubular scaffolding (Parts 1 & 2)
15) IS: 2571 Code of practice for laying insitu cement concrete flooring.
16) IS: 7861 Code of practice for extreme weather concreting: Part 1 Recommended practice for hot weather concreting.
17) IRC: 112 Code of practice for Concrete Road Bridges.
18) IRC: 78 Standard Specifications and Code of Practice for Road Bridges.
18) IRC: 21 Standard Specifications and Code of Practice for Road Bridges.
19) IS: 919 Recommendation for limits and fits for engineering.
20) IS: 1597 Construction of Stone Masonry (Part I & II)

4.1.8 Construction Safety

1) IS: 3696 Safety code for scaffolds and ladders. (Parts 1 & 2)
2) IS: 7969 Safety code for handling and storage of building materials.
3) IS: 8989 Safety code for erection of concrete framed structures.

4.1.9 Measurement

1) IS: 1200 Method of measurement of building and Engineering works
2) IS: 3385 Code of practice for measurement of Civil Engineering works

4.2 General

The Engineer shall have the right at all times to inspect all operations including the sources of materials, procurement, layout and storage of materials, the concrete batching and mixing equipment and the quality control system. Such an inspection shall be arranged and the Engineer's approval obtained, prior to starting of concrete work. This shall, however, not relieve the Contractor of any of his responsibilities. All materials which do not conform to the Specifications shall be rejected.

Materials should be selected so that they can satisfy the design requirements of strength, serviceability, safety, durability and finish with due regards to the functional requirements and the environmental conditions to which the structure will be subjected. Materials complying with codes/standards shall generally be used. Other materials may be used after approval of the Engineer and after establishing their performance suitability based on previous data, experience or tests.

4.3 Materials

4.3.1 Cement

Unless otherwise called for by the Engineer, cement shall be ordinary Portland cement conforming to IS: 269. Where Portland pozzolana or slag cements are used, it shall be ensured that consistency of quality is maintained, there will be no adverse interactions between the materials and the finish specified is not marred.
Only one type of cement shall be used in any one mix. The source of supply, type or brand of cement within the same structure or portion thereof shall not be changed without approval from the Engineer. Damaged or reclaimed or partly set cement will not be permitted to be used and shall be removed from the site. The storage bins and storage arrangement shall be approved by the Engineer. Consignments of cement shall be stored as received and shall be consumed in the order of their delivery. Storage of cement shall be as per standard practices.

Cement which is not used within 90 days from its date of manufacture shall be tested at a laboratory approved by the Engineer and until the results of such tests are found satisfactory, it shall not be used in any work.

4.3.2 Aggregates (General)

Aggregates shall consist of naturally occurring stones (crushed or uncrushed), gravel and sand. They shall be chemically inert, strong, hard, clean, durable against weathering, of limited porosity, free from dust/silt/ organic impurities/deleterious materials and all characteristics of aggregates conform to IS: 383.

Aggregates such as slag, crushed over burnt bricks, bloated clay ash, sintered fly ash and tiles shall not be used.

Aggregates shall be washed and screened before use where necessary or if directed by the Engineer. Aggregate source shall be approved by BWSSB.

Aggregates containing reactive materials shall be used only after tests conclusively prove that there will be no adverse effect on strength, durability and finish, including long term effects, on the concrete.

The fineness modulus of sand shall neither be less than 2.2 nor more than 3.2.

The maximum size of coarse aggregate shall be as stated on the drawings but in no case greater than 1/4 of the minimum thickness of the member.

Plums 160 mm and above of a reasonable size may be used in mass concrete fill where directed. Plums shall not constitute more than 20% by volume of the concrete.
The natural/ river sand to be used shall be clean, sieved and of good quality. As far as possible natural/ river sand shall be used. Whenever there is scarcity of natural/ river sand, manufactured sand / crushed sand can be used to a maximum extent of 50% of total sand quantity for plastering items and 100% for concrete items. The certification by the concerned Executive Engineer, Quality Control is mandatory for usage of artificial/ manufactured sand.

All coarse and fine aggregates shall be stacked separately in stock piles in the material yard near the work site in bins properly constructed to avoid inter mixing of different aggregates. Contamination with foreign material and earth during storage and while heaping the materials shall be avoided. The aggregates must be of specified quality not only at the time of receiving at site but more so at the time of loading into mixer. Rakers shall be piled in layers not exceeding 1.20 m in height to prevent coning or segregation. Each layer shall cover the entire area of stockpile before succeeding layers are started. Aggregates that have become segregated shall be rejected.

4.3.3 Water

Water used for both mixing and curing shall conform to IS: 456. Potable waters are generally satisfactory. Water containing any excess of acid, alkali, sugar or salt shall not be used. Contractor shall also use treated water being sold by BWSSB, to end exploitation of ground water.

4.3.4 Reinforcement

In general, reinforcement shall conform to TMT-CRS-500 and other reinforcement bars shall conform to IS: 432 or IS: 1786 and welded wire fabric to IS: 1566 as shown or specified on the drawing.

All reinforcement shall be clean, free from pitting, oil, grease, paint, loose mill scales, rust, dirty, dust, or any other substance that will destroy or reduce bond.

4.3.5 Admixtures

Accelerating, retarding, water-reducing and air entraining admixtures shall conform to IS: 9103 and integral water proofing admixtures to IS: 2645.

Admixtures may be used in concrete as per manufacturer's instructions only with the approval of the Engineer. An admixture's suitability and effectiveness shall be verified by trial mixes with the other materials used in the works. If two or more admixtures are to be used simultaneously in the same concrete mix, their interaction shall be checked and trial mixes done to ensure their compatibility. There should also be no increase in risk of corrosion of the reinforcement or other embedment.

Calcium chloride shall not be used for accelerating set of the cement for any concrete containing reinforcement or embedded steel parts. When calcium chloride is permitted such as in mass concrete works, it shall be dissolved in water and added to the mixing water by an amount not exceeding 1.5 percent of the weight of the cement in each batch of concrete. The designed concrete mix shall be corrected accordingly.

4.3.5.1 Air Entraining Agents

Neutralized Vinson resin or other approved air in the concrete mix agents shall conform to the requirements of ASTM standard 6.260; Air Entraining Admixtures for Concrete. The recommended total air content of the concrete is 4% + 1%. The method of measuring air content shall be as per IS: 1199.

4.3.5.2 Water Reducing Admixtures

Water reducing lignosulfonate admixture may be added in quantities approved by the Engineer. The admixtures shall be added in the form of a solution.

4.3.5.3 Retarding Admixtures

Retarding agents may be added to the concrete mix in quantities approved by the Engineer.

4.3.5.4 Water Proofing Agent

Water proofing agents shall conform to IS: 2645.

4.3.5.5 Other Admixtures

The Engineer may at his discretion allow the contractor to use any other admixture in the concrete.

4.4 Wastage

Wastage allowance for cement and steel and higher rolling margin for steel shall be considered in the item rate and no extra payment shall become payable to the Contractor on any account.

4.5 Samples and Tests

All materials used for the works shall be tested before use. Manufacturer's test certificate shall be furnished for each batch of cement/steel and when directed by the Engineer samples shall also be got tested by the Contractor in a laboratory approved by the Engineer at no extra cost to Employer. Sampling and testing shall be as per IS: 2386 under the supervision of the Engineer. Water to be used shall be tested to comply with requirements of IS: 456.

The Contractor shall furnish manufacturer's test certificates and technical literature for the admixture proposed to be used. If directed, the admixture shall be got tested at an approved laboratory at no extra cost.

4.6 Storing of Materials

All materials shall be stored in a manner so as to prevent its deterioration and contamination which would preclude its use in the works. Requirements of IS: 4082 shall be complied with.

The Contractor will have to make his own arrangements for the storage of adequate quantity of cement. If such cement is not stored properly and has deteriorated, the material shall be rejected. Cement bags shall be stored in dry weatherproof shed with a raised floor, well away from the outer walls and insulated from the floor to avoid moisture from ground. Not more than 15 bags shall be stacked in any tier. Storage arrangement shall be approved by the Engineer. Storage under tarpaulins shall not be permitted. Each consignment of cement shall be stored separately and consumed in its order of receipt.

Each size of coarse and fine aggregates shall be stacked separately and shall be protected from leaves and contamination with foreign material. The stacks shall be on hard, clean, free draining bases, draining away from the concrete mixing area.

The Contractor shall make his own arrangements for storing water at site in tanks to prevent contamination.

The reinforcement shall be stacked on top of timber sleepers to avoid contact with ground/water. Each type and size shall be stacked separately.

4.7 Concrete

4.7.1 General

Concrete grade shall be as designated on drawings. In concrete grade M15, M20 etc. the number represents the specified characteristic compressive strength of 150 mm cube at 28 days, expressed in N/sq.mm as per IS:456. Concrete in the works shall be "DESIGN MIX CONCRETE" or "NOMINAL MIX CONCRETE". All concrete works of grade M10 and M15 shall be NOMINAL MIX CONCRETE whereas all other grades, M20 and above, shall be DESIGN MIX CONCRETE.
The grades of concrete to be used are noted on the drawings. In addition, the following table shall apply unless specified otherwise.

Structure	Grade of Concrete	Max. Aggregate Size
1. All Liquid retaining structures / Wet wells/ Bridges/ Piles/ Pile caps	M30	20 mm
2. Sewage Pumping Stations/ Buildings		
(a) for foundation raft	M25	20 mm
(b) for walls, columns, floor beams, circular floor slab	M25	20 mm
(c) for beams, slabs etc.	M25	20 mm
3. Valve chambers		
(a) for foundation raft	M25	20 mm
(b) walls, columns	M25	20 mm
(c) for slabs, beams, etc.	M25	20 mm
4. Anchor blocks/ Thrust blocks/ Antiflotation blocks	M20	40 mm
5. Saddles	M25	20 mm
6. Pipeline encasement, grade slab, ramps, footings under walls, SW drain coping etc	M20	20 mm
7. Bridges		
Foundation of piers and abutments	M30	20 mm
Piers and abutments with wing walls	M30	20 mm
Hammer head of pipes	M30	20 mm
8. Causeway	M25	20 mm
9. Machine holes	M30	20 mm

4.7.2 Controlled Concrete

All concrete in the works shall be “Controlled Concrete” as defined in IS: 456 except for M-10 for which normal mix concrete shall be used.

Note: It shall be very clearly understood that whenever the grade of concrete such as M-20, etc. is specified it shall be contractor’s responsibility to ensure the minimum crushing strength stipulated for the respective grade of concrete is obtained at works.

4.7.3 Design Mix Concrete

4.7.3.1 Mix Design & Testing

For Design Mix Concrete, the mix shall be designed according to IS: 10262 and SP: 23 to provide the grade of concrete having the required workability and characteristic strength not less than appropriate values given in IS: 456. The design mix shall in addition be such that it is cohesive and does not segregate and should result in a dense and durable concrete and also capable of giving the finish as specified. For liquid retaining structures, the mix shall also result in water tight concrete. The Contractor shall exercise great care while designing the concrete mix and executing the works to achieve the desired result based on SP23 Fig 37 of minimum cement paste volume in concrete for durability.

The minimum cement content for Design Mix Concrete shall be as per Table-5 of IS: 456 and for Pile foundations as per IS: 2911 or as given below, whichever is higher.

Grade of Concrete	Minimum Cement Content in Kg/Cu.m of Concrete
M20	320
M25	360
M30	400

The minimum cement content stipulated above shall be adopted irrespective of whether the Contractor achieves the desired strength with less quantity of cement. The Contractor's quoted rates for concrete shall provide for the above eventuality and nothing extra shall become payable to the Contractor in this account. Even in the case where the quantity of cement required is higher than that specified above to achieve desired strength based on an approved mix design, nothing extra shall become payable to the Contractor.

The Contractor shall submit details of the source of all material and the proposed quantities of each ingredient per cubic metre of fully compacted concrete. The Contractor shall then make trial mixes for each class of concrete using the same Contractor's Equipment and the same materials as are proposed for the Permanent Works. The Contractor shall give 24 hours notice of such trials to enable the Engineer's Representative to attend. For each trial mix, three separate batches of concrete shall be made by the Contractor and will be tested at 28 days all in accordance with IS: 516. Such trial mixes shall not be the first batch through the plant in any one sequence of concrete production.

The Contractor shall not commence concreting in the Permanent Works until details of trial mixes and test results for each class of concrete have been submitted to and approved by the Engineer.

Unless otherwise specified, only medium graded fine aggregate shall be used.
A trial mix design will be approved by the Engineer with respect to strength if the average compressive strength of the nine cubes so tested is more than the target means strength appropriate to the grade of concrete.

For concrete of Grade 30 and over the Contractor shall cast two sample wall panels 48 hours apart. Each shall be cast in two equal lifts to form a wall panel having one horizontal construction joint formed in the manner proposed by the Contractor for the Works. The top surface of the second lift shall have a Type U3 finish. The panels shall not be touched up after stripping. The panels shall be 300 mm thick and 1.5 m long by 1.5 m high. The Contractor shall not commence concreting in the Permanent Works until the test panels have been approved by Engineer.

The Contractor shall not alter the approved mix proportions or the approved source of supply of any of the ingredients without having previously obtained the approval of the Engineer.
During production, the Engineer may require trial mixes to be made before a substantial change is made in the materials or in the proportions of the materials to be used.
It shall be the Contractor's sole responsibility to carry out the mix designs at his own cost. He shall furnish to the Engineer at least 30 days before concreting operations, a statement of proportions proposed to be used for the various concrete mixes and the strength results obtained. The strength requirements of the concrete mixes ascertained on 150 mm cubes as per IS:516 shall comply with the requirements of Clause 16 of IS:456.

A range of slumps which shall generally be used for various types of construction unless otherwise instructed by the Engineer is given below:

4.7.3.2 Workability

The workability of concrete shall be checked at frequent intervals by slump test. Where facilities exist and if required by the Engineer, alternatively the compacting factor test in accordance with IS: 1199 shall be carried out. The degree of workability necessary to allow the concrete to be well consolidated and to be worked into the corners of form work and round the reinforcement to give the required surface finish shall depend on the type and nature of the structure and shall be based on experience and tests

4.7.3.3 Workmanship

All workmanship shall be according to the latest relevant standards. Before starting a pour the contractor shall obtain the approval of the Engineer in a "Pour Card" maintained for this purpose. He shall obtain complete instructions about the material and proportion to be used, slump, workability of water per unit of cement, number of test cubes to be taken, finishing to be done and any admixture to be added etc

Structure/Member	**Slump in millimeters**	
	Maximum	**Minimum**
Reinforced foundation walls and footings	75	40
Plain footings, caissons and substructure walls	75	40
Slabs, Beams and reinforced walls	100	50
Pump & miscellaneous Equipment Foundation	75	40
Building columns	100	40
Pavements	50	40
Heavy mass construction	50	40

Note: All concreting done for water retaining structures shall have a minimum slump value of 80 mm and maximum of 100 mm

4.7.3.4 Batching & Mixing of Concrete

It is expected that batching plants of minimum 30 m^3 capacity, with two silos and pumps for placing concrete shall be used. Proportions of aggregates and cement, as decided by the concrete mix design, shall be by weight. These proportions shall be maintained during subsequent concrete batching by means of weigh batchers capable of controlling the weights within one percent of the desired value.

Amount of water added shall be such as to produce dense concrete of required consistency, specified strength and satisfactory workability and shall be so adjusted to account for moisture content in the aggregates. Water- cement ratio specified for use by the Engineer shall be maintained. Each time the work stops, the mixer shall be cleaned out, and while recommencing, the first batch shall have 10% additional cement to allow for sticking in the drum.

Arrangement should be made by the Contractor to have the cubes tested in an approved laboratory or in field with prior consent of the Engineer. Sampling and testing of strength and workability of concrete shall be as per IS: 1199, IS: 516 and IS: 456.

4.7.4 Nominal Mix Concrete

4.7.4.1. Mix Design & Testing

Mix design and preliminary tests are not necessary for Nominal Mix Concrete. However, works tests shall be carried out as per IS: 456. Proportions for Nominal Mix Concrete and w/c ratio may be adopted as per Table 9 of IS: 456. However, it will be the Contractor's sole responsibility to adopt appropriate nominal mix proportions to yield the specified strength.

4.7.4.2. Batching & Mixing of Concrete

Based on the adopted nominal mixes, aggregates shall be measured by volume. However cement shall be by weight only, using whole bags of cement.

4.8 Formwork

Formwork shall be all inclusive not be limited to shores, bracings, sides of footings, walls, beams and columns, bottom of slabs etc. including ties, anchors, hangers, inserts, falsework, wedges etc.

The design and engineering of the formwork as well as its construction shall be the responsibility of the Contractor. However, if so desired by the Engineer, the drawings and calculations for the design of the formwork shall be submitted to the Engineer for approval.

Formwork shall be designed to fulfill the following requirements:

1. Sufficiently rigid and tight to prevent loss of grout or mortar from the concrete at all stages and appropriate to the methods of placing and compacting.

2. Made of suitable materials.

3. Capable of providing concrete of the correct shape and surface finish within the specified tolerance limits.

4. Capable of withstanding without deflection the worst combination of selfweight, reinforcement and concrete weight, all loads and dynamic effects arising from construction and compacting activities, wind and weather forces.

5. Capable of easily striking without shock, disturbance or damage to the concrete.

6. Soffit forms capable of imparting a camber if required.

7. Soffit forms and supports capable of being left in position if required.

8. Capable of being cleaned and/or coated if necessary immediately prior to casting the concrete. design temporary openings where necessary for these purposes and to facilitate the preparation of construction joints.

The formwork may be of timber, plywood, steel, plastic or concrete depending upon the type of finish specified. Sliding forms and slip form may be used with the approval of the Engineer. Timber for formwork shall be well seasoned, free from sap, shakes, loose knots, worm holes, warps and other surface defects. Joints between formwork and formwork and between formwork and structures shall be sufficiently tight to prevent loss of slurry from concrete, using seals if necessary.

The faces of formwork coming in contact with concrete shall be cleaned and two coats of approved mould oil applied before fixing reinforcement. All rubbish, particularly chippings, shavings, sawdust, wire pieces dust etc. shall be removed from the interior of the forms before the concrete is placed. Where directed, cleaning of forms shall be done by blasting with a jet of compressed air at no extra cost.

Forms intended for reuse shall be treated with care. Forms that have deteriorated shall not be used. Before reuse, all forms shall be thoroughly scraped, cleaned, nails removed, holes suitably plugged, joints repaired and warped lumber replaced to the satisfaction of the Engineer. The Contractor shall equip himself with enough shuttering to allow for wastage so as to complete the job in time.

Permanent formwork shall be checked for its durability and compatibility with adjoining concrete before it is used in the structure. It shall be properly anchored to the concrete.

Wire ties passing through beams, columns and walls shall not be allowed. In their place bolts passing through sleeves shall be used. Formwork spacers left insitu shall not impair the desired appearance or durability of the structure by causing spalling, rust staining or allowing the passage of moisture.

For liquid retaining structures, sleeves shall not be provided for through bolts nor shall through bolts be removed if provided. The bolts, in the latter case, shall be cut at 25 mm depth from the surface and the hole made good by cement mortar of the same proportion as the concrete just after striking the formwork.

All corners and angles exposed in the finished structure shall have chamfers or fillets of 20 mm x 20 mm size, except where specified in the drawings.

Forms for substructure may be omitted when, in the opinion of the Engineer, the open excavation is firm enough (in hard non-porous soils) to act as a form. Such excavations shall be larger, as approved by the Engineer, than that required as per drawing to compensate for irregularities in excavation.

The Contractor shall provide adequate props carried down to a firm bearing without overloading any of the structures.

The shuttering for beams and slabs shall be so erected that the side shuttering of beams can be removed without disturbing the bottom shuttering. If the shuttering for a column is erected for the full height of the column, one side shall be built up in sections as placing of concrete proceeds or windows left for placing concrete from the side to limit the drop of concrete to 1.0m or as approved by the Engineer. The Contractor shall temporarily and securely fix items to be cast (embedment's/ inserts) in a manner that will not hinder the striking of forms or permit loss of grout.

Formwork showing excessive distortion, during any stage of construction, shall be repositioned and strengthened. Placed concrete affected by faulty formwork, shall be entirely removed and formwork corrected prior to placement of new concrete at Contractor's cost.

The striking time for formwork shall be determined based on the following requirements:

(a) Development of adequate concrete strength;
(b) Permissible deflection at time of striking form work;
(c) Curing procedure employed - its efficiency and effectiveness;
(d) Subsequent surface treatment to be done;
(e) Prevention of thermal cracking at re-entrant angles;
(f) Ambient temperatures; and

(g) Aggressiveness of the environment (unless immediate adequate steps are taken to prevent damage to the concrete).

Under normal circumstances (generally where temperatures are above 20°C) forms may be struck after expiry of the time period given in IS: 456 unless approved otherwise by the Engineer. For Portland Pozzolana/slag cement the stripping time shall be suitably modified as approved by the Engineer. It is the Contractor's responsibility to ensure that forms are not struck until the concrete has developed sufficient strength to support itself, does not undergo excessive deformation and resist surface damage and any stresses arising during the construction period.

4.9 Removal of Formwork

Formwork shall be so designed as to permit any removal without resorting to hammering or levering against the surface of the concrete. The periods of time elapsing between the placing of the concrete and the striking of the loads likely to be imposed on the concrete and shall in any case be not less than the periods, shown in Table below. Where soffit formwork is constructed in a manner during and after such removal of a sufficient number of adequate supporting props in an undisturbed condition, the Contractor may, with the agreement of the Engineer, remove the formwork at the earlier times listed below provided that the props are left in position.

Table 12

Position of Formwork	Days for Striking
Walls	1
Sides of beams and columns	1
Slabs (Drops left under)	3
Props to slabs (span not exceeding 4.5m)	7
Props to slabs (span exceeding 4.5 m)	14
Beams soffits (props left under)	21

Not withstanding the foregoing, the Contractor shall be held responsible for any damage arising from removal of formwork before the structure is capable of carrying its own weight and any incidental loading.

Striking shall be done slowly with utmost care to avoid damage to projections and without shock or vibration, by gently easing the wedges. If after removing the form work it is found that timber has been embedded in the concrete. It shall be removed and made good as specified earlier.

Reinforced temporary openings shall be provided, as directed by the Engineer, to facilitate removal of formwork which otherwise may be inaccessible.

The rods, clamps, form bolts, etc. which must be entirely removed from walls or similar structures shall be loosened not sooner than 24 hours not later than 40 hours after the concrete has been deposited. Ties, except those required to hold forms in place, may be removed at the same time. Ties, withdrawn from walls and grade beams shall be pulled toward the inside face. Cutting ties back from the faces of the walls and grade beams will not be permitted.

4.10 Technical Specifications for Sheet Piling

4.10.1 General

Sheet piling is a form of driven piling using interlocking sheets of steel to obtain a continuous barrier in the ground. The main application of sheet pile is in retaining walls erected for the purpose of excavation to enable permanent works to proceed. Normally vibrating hammer/ impact hammer, crane and crawler drilling are to be used to establish sheet piles. The work shall be done as per BOQ provisions. The work shall include supply, installation and subsequent removal of all miscellaneous steel shapes, plates and connecting hardware when required to attach the sheeting to an existing substructure unit and/or facilitate stage construction.

All initial banking has to be formed at contractor's own cost for taking the machinery to drive the sheet piles. The area shall be filled driving of steel sheet piles with pit sand for leveling the ground.

Piles shall be driven, true to plumb and alignment. Hammer for sheet pile driving shall be drop hammer, steam hammer, air hammer, diesel hammer or vibratory hammer. Sheet pile driving shall commence initially with minimum impact of hammer, which can be increased later after ensuring that the piles are being driven vertically through the interlocking grooves along with designed alignment. The sheet piles are to be driven with batten welded at suitable intervals. The Steel Sheet Pile may be lifted at single point

4.10.2 Applicable Code

All work shall be carried out strictly in accordance with the Technical Specifications, unless otherwise approved by Engineer in writing. The Indian Standard Codes applicable to this section shall include but not limited to the following.

IS 2314:1986 Specification for steel sheet piling sections (first revision)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 6/A 6M (2000) General Requirements for Rolled Structural Steel Bars,

Plates, Shapes, and Sheet Piling

ASTM A 328/A 328M (200) Steel Sheet Piling

ASTM A 572/A 572M (200) High-Strength Low-Alloy Columbium-Vanadium

Structural Steel

ASTM A 690/A 690M (1994) High-Strength Low-Alloy Steel H-Piles and

Sheet Piling for Use in Marine Environments

ASTM A 857/A 857M (1997el) Steel Sheet Piling, Cold Formed, Light Gage.

4.10.3 Transportation

The Contractor shall set up, in accordance with the construction schedule make all the necessary arrangements for hauling of all materials for the steel sheet pile driving so that all the materials will be available for immediate use whenever required:

a) All the steel sheet piles shall be delivered intact at the site without causing any permanent distortion in the member or injury or deformation at joints.

b) Care shall be taken in handling such materials as tie-rods to avoid damage to the thread and shop coat painting.

c) Handling of such long members as walling shall be carried out in the same way as for the steel sheet piles.

4.10.4 Storage

a) Storage space for steel sheet piles shall be reasonably leveled and compacted. The site so selected should be got approved by the ENGINEER.

b) Steel sheet piles shall be stacked in such a way as to avoid strain or distortion in the materials.

c) Steel sheet piles shall be stacked up in such tiers as each consisting of not more than 3 piles, and between each tier wooden sleepers shall be inserted at intervals not exceeding 4m. Total height of stack shall not exceed 2m.

d) Tie-rods and accessories shall be sorted, stacked in accordance with their diameters and shall be stored under cover and not be directly exposed to weather.

e) The Contractor shall be responsible for safe handling, mobilization & demobilization and storage of piles and other materials. The rate for sheet pile driving shall include the cost for handling and storage of piles and other accessories, forming driving pit, formation and removal of earthen bund if required, all other requisites for successful driving of sheet pile.

4.10.5 Cutting of Sheet Pile

a) Cutting of steel sheet piles shall be done by means of a gas cutting device.

b) Steel sheet piles to be cut shall be free from curve and warp, and securely clamped on a level work table for cutting.

c) Use of a special jig is desirable to minimize deformation due to cutting

d) Whatever method is used in cutting, a certain degree of deformation is bound to occur. If the deformation is less than 40mm, it can be set right by hammering or by heat treatment to the deformed segment. If the deformation exceeds the above range, mechanical correction by means of jacks and press shall be made.

4.10.6 Sheet Pile Welding

a) Arc welding shall be adopted for steel sheet pile work.

b) Only skilled welders approved by the ENGINEER shall be engaged for the work.

c) Welding equipment shall be AC rectifiers / arc-welding unit. Welding rods shall be those conforming to the relevant IS or equivalent and subject to prior approval of ENGINEER.

d) If any welding is rejected by the ENGINEER, the Contractor shall perform the welding again by cutting off at the weld at his cost. All the costs thereof shall be borne by the Contractor.

4.10.7 Materials

Metal sheet piling material shall be conforming to IS:2314 or equivalent ASTM standards. The interlocks of sheet piling shall be free-sliding, provide a swing angle suitable for the intended installation but not less than 5 degrees when interlocked, and maintain continuous interlocking when installed. Sheet piling [including special abricated sections] shall be [full-length] sections of the dimensions as shown in the drawing. Sheet piling shall be provided with standard pulling holes.

Metal plates, shapes, bolts, nuts, rivets, and other appurtenant fabrication and installation materials shall conform to manufacturer's standards and to the requirements specified in the respective sheet piling.

4.10.8 Extraction of Rejected Sheet Pile:

If the pile driving work has not been done to the specification, the Contractor shall extract the rejected pile. The extraction shall be such as to avoid damages to the adjoining piles, other structures and installations. Cost of extraction and replacement shall be borne by the Contractor.

4.10.9 Construction

The Contractor shall verify locations of all underground utilities before driving any sheet piling. Any disturbance or damage to existing structures, utilities or other property, caused by the Contractor's operation, shall be repaired by the Contractor in a manner satisfactory to the Engineer at no additional cost to the Department. The Contractor shall be responsible for determining the appropriate equipment necessary to drive the sheeting to the tip elevation(s) specified on the plans or according to the Contractor's approved design. The Contractor shall be responsible for determining the appropriate equipment necessary to drive the sheeting to the tip elevation(s) specified on the plans or according to the Contractor's approved design. The sheet piling shall be driven, as a minimum, to the tip elevation(s) specified, prior to commencing any related excavation. If unable to reach the minimum tip elevation, the adequacy of the sheet piling design will require re-evaluation by the PMC/ Owner prior to allowing excavation adjacent to the sheet piling in question. The Contractor shall not excavate below the maximum excavation line shown on the plans without the prior permission of the Engineer. The sheet piling shall remain in place until the Engineer determines it is no longer required.

The sheet piling shall be removed and take away from site by the Contractor when directed by the Engineer. When allowed, the Contractor may elect to cut off a portion of the sheet piling leaving the rest in place. The remaining piling shall be a minimum of 12 in. (300 mm) below the finished grade or as directed by the Engineer. Removed sheet piling becomes the property of the Contractor. When an obstruction is encountered, the Contractor shall notify the Engineer and upon concurrence of the Engineer, the Contractor shall begin working to break up, push aside, or remove the obstruction. An obstruction shall be defined as any object (such as but not limited to, boulders, logs, old foundations etc.) where its presence was not obvious or specifically noted on the plans prior to bidding, that cannot be driven through or around with normal driving procedures, but requires additional excavation or other procedures to remove or miss the obstruction.

The following are the installation procedures:

1 The alignment of sheet pile wall shall be correctly set up for the approval of the ENGINEER before commencing the sheet pile driving.

2 Guide frames and stakes shall be installed correctly and secured properly to ensure driving of piles on the centre line.

3 Steel sheet pile driving shall be performed by one of the following methods.

a) In driving single pile one by one, special care shall be exercised to keep each pile penetrating in strictly vertical direction.

b) In driving a group of piles (about 20 pieces simultaneously) a guide frame shall be used to keep them in a straight alignment, and in the initial stage all the piles shall be driven to a depth just enough to enable them to stand in positions. Then one or two pieces on both ends shall be driven down first, followed by the intermediate piles which shall be driven alternately in several stages to final level.

4 Prior to starting pile driving, the Contractor shall submit the driving method and time schedule for approval of the ENGINEER and in accordance with the sequence approved by the ENGINEER. The piles shall be driven vertically in the specified positions.

5 Pile driving:

a) Sheet pile driving shall commence initially with minimum impact of hammer and increased later after ensuring that the piles are being driven vertically in designed alignment.

b) Pile shall be driven with cap and cushion on top of the pile for protection against the impact of drop hammer.

c) Lengthening of pile, if required, shall be done by welding additional piece on to the top of pile already driven. The joints shall be as strong as the normal section of the pile.

d) In case interlocks of piles with adjacent ones are found loosened or dislocated during or after driving, such piles shall be pulled out and replaced with new ones or redone otherwise in accordance with instructions of the ENGINEER.

e) The Contractor shall take every step to ensure safety and to prevent accident while handling and driving piles. If any deviation from specified lines, fractured top, deficient or excessive penetration is observed during pile driving, the driving shall be suspended to take corrective measures as directed by the ENGINEER.

f) Necessary data and logs such as of the number of blows, length of penetration etc. during sheet pile driving shall be made and submitted in duplicate to the ENGINEER at no extra cost. Format of driving log shall be got approved by ENGINEER prior to commencement of driving sheet piles.

6 Reformed steel sheet piles:

a) Reformed steel sheet piles shall be of three types, namely corner sheet pile, junction sheet pile and wedge sheet pile.

b) Corner sheet piles are used where centre line for driving turns to form an angle, and joined by welding to the sheet pile wall that has changed its direction.

c) Junction sheet piles are those to be used where two walls of sheet piles meet at right angle forming a T junction, and where the sizes of sheet pile change along the same line.

d) Wedge sheet piles are used to make up for the deviation of piles from the plumb line caused during driving. This type of pile is characterized by its wedge like shape, tapering downward to the tip.

e) Reformed steel sheet piles as mentioned above shall as a rule is manufactured in a factory. If it becomes inevitable to fabricate them in the field at site, the Contractor shall provide equipment and manufacturing means equivalent to those of the regular factory production and have close supervision and control over driving.

f) If the Contractor finds it necessary to use the reformed steel sheet piles, he shall obtain approval of the ENGINEER for the use, and fabricate the same at his own cost in accordance with the instructions of the ENGINEER.

4.10.10 Payment for Steel Sheet Piling

It may be noted that the measurement shall be taken for one side of the trench only and the Contractor shall be paid for one side only even though sheet pilling work is provided for both sides trench in accordance with the Contract drawings or as directed by the Engineer. The unit rate for steel sheet pile driving shall include the costs of material, transportation, driving and incidental costs towards

replacement of the damaged steel sheet piles. The cost will also include the cost of waling and accessories.

4.11 Reinforcement Workmanship

Reinforcing bars supplied bent or in coils shall be straightened cold without damage. No bending shall be done when ambient temperature is below 5^{o}C. Local warming may be permitted if steel is kept below 100^{o} C.

All bars shall be accurately bent gradually and according to the sizes and shapes shown on the drawings/ schedules or as directed by the Engineer.
Re-bending or straightening incorrectly bent bars shall not be done without the approval of the Engineer.

Reinforcement shall be accurately fixed and maintained firmly in the correct position by the use of blocks, spacers, chairs, binding wire etc. to prevent displacement during placing and compaction of concrete. The tied in place reinforcement shall be approved by the Engineer prior to concrete placement. Spacers shall be of such materials and designs as will be durable, not lead to corrosion of the reinforcement and not cause spalling of the concrete cover.

Binding wire shall be 16 gauge soft annealed wires. Ends of the binding wire shall be bent away from the concrete surface and in no case encroach into the concrete cover.
Substitution of reinforcement, laps/splices not shown on drawing shall be subject to Engineer's approval.

4.12 Tolerances

Tolerance is a specified permissible variation from lines, grade or dimensions given in drawings. No tolerance specified for horizontal or vertical building lines or footings shall be construed to permit encroachment beyond the legal boundaries. Tolerance for formed and concrete dimensions shall be as per IS:456 unless specified otherwise.

4.12.1 Tolerances for R.C. Buildings

Variation from the Plumb

(i) In the lines and surfaces of columns, piers, walls and in arrises 5 mm per 2.5 m or 25 mm, whichever is less.

(ii) For exposed corner columns and other conspicuous lines

In any bay or 5 m maximum	-	5 mm
In 10 m or more	-	10 mm

Variation from the level or from the grades indicated on the drawings

(i) In slab soffits, ceilings, beam soffits, and in arises

In 2.5 m	-	5 mm
In any bay or 5 m maximum	-	10 mm
In 10 m or more	-	15 mm

(ii) For exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines :

In any bay or 5 m maximum	-	5 mm
In 10 m or more	-	10 mm

Variation of the linear building lines from established position in plan and related position of columns, wall and partitions :

In any bay or 5 m maximum	-	10 mm
In 10 m or more	-	20 mm

Variation in the sizes and locations of sleeves, openings in walls and floors – 5 mm except in the case anchor bolts.

Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls

Minus - 5 mm
Plus - 10 mm

Footings

(i) Variation in dimension in plan
Minus - 5 mm
Plus - 50 mm

(ii) Misplacement or eccentricity
2% of footing width in the direction of misplacement but not more than 50 mm

(iii) Reduction in thickness
Minus - 5% of specified thickness subject to a maximum of 50 mm

Variation in steps

(i) In a flight of stairs
Rise - 3 mm
Tread - 5 mm

(ii) In consecutive steps
Rise - 1.5 mm
Tread - 3.0 mm

4.12.2 Tolerances in other structures

All structures

(i) Variation of the construction linear outline from established position in plan
In 5 m - 10 mm
In 10 m or more - 15 mm

(ii) Variations of dimensions to individual structure features from established positions
In 20 m or more - 25 mm
In buried construction - 50 mm

(iii) Variation from plumb, from specified batter or from curved surfaces of all structures
In 2.5 m - 10 mm
In 5 m - 15 mm
In 10 m or more - 25 mm
In buried construction - Twice the above amounts

(iv) Variation from level or grade indicated on drawings in slab, beams, soffits, horizontal grooves and visible arises.
In 2.5 m - 5 mm
In 7.5 m or more - 10 mm
In buried construction - Twice the above amounts

(iv) Variation in cross-sectional dimensions of columns, beams, buttresses, piers and similar members
Minus - 5 mm
Plus - 10 mm

(vi) Variation in the thickness of slabs, walls, arch sections and similar members
Minus - 5 mm
Plus - 10 mm

Footing for columns, piers, walls, buttresses and similar members

(i) Variation of dimension in plan
Minus - 10 mm
Plus - 50 mm

(ii) Misplacement or eccentricity
2% footing width in the direction of misplacement but not more than 50 mm

(iii) Reduction in thickness
5% of specified thickness subject to a maximum of 50 mm.

Tolerance in fixing anchor bolts shall be as follows:

(i) Anchor bolts without sleeves	:	1.5 mm in plan
(ii) Anchor bolts with sleeves	:	5.0 mm in elevation
- for bolts upto and including 28 mm dia	:	5 mm in all directions
- for bolts 32 mm dia and above	:	3 mm in all directions
(iii) Embedded parts	:	5 mm in all directions

4.12.3 Tolerances in Formwork:

The formwork shall be designed and constructed to the shapes, lines and dimensions shown on the drawings within the tolerances given below:

(i)	Deviation from specified dimensions of cross section of columns and beams	- 6 mm + 12 mm
(ii)	Deviations from dimensions of footings (Tolerances apply to concrete dimensions only, not to positioning of vertical reinforcing steel or dowels)	
	- Dimension in plan	- 12 mm + 50 mm
	- Eccentricity	0.02 times the width of the footing in the direction of deviation but not more than 50 mm
	- Thickness	± 0.05 times the specified thickness

4.13 Preparation Prior to Concrete Placement

Before concrete is actually placed in position, the inside of the formwork shall be cleaned and mould oil applied, inserts and reinforcement shall be correctly positioned and securely held, necessary openings, pockets, etc. provided.

All arrangements-formwork, equipment and proposed procedure, shall be approved by the Engineer. Contractor shall maintain separate Pour Card for each pour as per the format enclosed.

4.14 Transporting, Placing and Compacting Concrete

Concrete shall be transported from the mixing plant to the formwork with minimum time lapse by methods that shall maintain the required workability and will prevent segregation, loss of any ingredients or ingress of foreign matter or water.

In all cases concrete shall be deposited as nearly as practicable directly in its final position. To avoid segregation, concrete shall not be rehandled or caused to flow. For locations where direct placement is not possible and in narrow forms the Contractor shall provide suitable drops and "Elephant Trunks". Concrete shall not be dropped from a height of more than 1.0m.
Concrete shall not be placed in flowing water. Under water, concrete shall be placed in position by tremies or by pipeline from the mixer and shall never be allowed to fall freely through the water.

While placing concrete the Contractor shall proceed as specified below and also ensure the following:

1. Continuously between construction joints and pre- determined abutments.
2. Without disturbance to forms or reinforcement.

3. Without disturbance to pipes, ducts, fixings and the like to be cast in; ensure that such items are securely fixed. Ensure that concrete cannot enter open ends of pipes and conduits etc.
4. Without dropping in a manner that could cause segregation or shock.
5. In deep pours only when the concrete and formwork designed for this purpose and by using suitable chutes or pipes.
6. Do not place if the workability is such that full compaction cannot be achieved.
7. Without disturbing the unsupported sides of excavations; prevent contamination of concrete with earth. Provide sheeting if necessary. In supported excavations, withdraw the linings progressively as concrete is placed.
8. If placed directly onto hardcore or any other porous material, dampen the surface to reduce loss of water from the concrete.
9. Ensure that there is no damage or displacement to sheet membranes.
10. Record the time and location of placing structural concrete.
11. Cover blocks of required size depending on the cover of the reinforcement as mentioned in the drawings should be prepared in 1:3 cement mortar with fine aggregates.
12. The top surface of each pour and bedding planes shall be approximately horizontal unless otherwise instructed. Top layer should be rough and with key for further extension of work.
13. Concrete shall be compacted during placing with approved vibrating equipment until the concrete has been consolidated to the maximum practicable density, as specified in the IS, is free of pockets of coarse aggregate and fits tightly against all form surfaces, reinforcement and embedded fixtures.
14. Vibrators shall conform to BIS specifications. Type of vibrator to be used shall depend on the structures where concrete is to be placed.
15. Bleeding or free water on top of concrete being deposited into the forms, shall be the cause to stop the concrete pour and the conditions causing this defect corrected before any further Concreting is resumed.

Concrete shall normally be compacted in its final position within thirty minutes of leaving the mixer. Concrete shall be compacted during placing with approved vibrating equipment without causing segregation until it forms a solid mass free from voids thoroughly worked around reinforcement and embedded fixtures and into all corners of the formwork.

Immersion vibrators shall be inserted vertically at points not more than 450 mm apart and withdrawn slowly till air bubbles cease to come to the surface, leaving no voids. When placing concrete in layers advancing horizontally, care shall be taken to ensure adequate vibration, blending and melding of the concrete between successive layers.

Vibrators shall not be allowed to come in contact with reinforcement, formwork and finished surfaces after start of initial set. Concrete may be conveyed and placed by mechanically operated equipment after getting the complete procedure approved by the Engineer. The slump shall be held to the minimum necessary for conveying concrete by this method. When concrete is to be pumped, the concrete mix shall be specially designed to suit pumping. Care shall be taken to avoid stoppages in work once pumping has started.

Except when placing with slip forms, each placement of concrete in multiple lift work, shall be allowed to set for at least 24 hours after the final set of concrete before the start of subsequent placement. Placing shall stop when concrete reaches the top of the opening in walls or bottom surface of slab, in slab and beam construction, and it shall be resumed before concrete takes initial set but not until it has had time to settle as approved by the Engineer. Concrete shall be protected against damage until final acceptance.

4.15 Mass Concrete Works

Sequence of pouring for mass concrete works shall be as approved by the Engineer. The Contractor shall exercise great care to prevent shrinkage cracks and shall monitor the temperature of the placed concrete if directed.

4.16 Curing

Curing and protection shall start immediately after the compaction of the concrete to protect it from:

1. Premature drying out, particularly by solar radiation and wind
2. Leaching out by rain and flowing water
3. Rapid cooling during the first few days after placing
4. High internal thermal gradients
5. Low temperature or frost
6. Vibration and impact which may disrupt the concrete and interfere with its bond to the reinforcement.

All concrete, unless approved otherwise by the Engineer, shall be cured by use of continuous sprays or ponded water or continuously saturated coverings of sacking, canvas, hessain or other absorbent material for the period of complete hydration with a minimum of 7 days. The quality of curing water shall be the same as that used for mixing.
Where a curing membrane is approved to be used by the Engineer, the same shall be of a non-wax base and shall not impair the concrete finish in any manner. The curing compound to be used shall be approved by the Engineer before use and shall be applied with spraying equipment capable of a smooth, even textured coat.

Curing may also be done by covering the surface with an impermeable material such as polyethylene, which shall be well sealed and fastened.

4.17 Construction Joints and Keys

Construction joints will be as shown on the drawing or as approved by the Engineer. Concrete shall be placed without interruption until completion of work between construction joints. If stopping of concreting becomes unavoidable anywhere, a properly formed construction joint shall be made with the approval of the Engineer.

Dowels for concrete work, not likely to be taken up in the near future, shall be coated with cement slurry and encased in lean concrete as indicated on the drawings or as approved by the Engineer.

As soon as the exposed concrete has sufficiently hardened, the surface of the joint shall be water jetted or brushed with a stiff brush to expose the larger aggregate without being disturbed. Roughening of the surface by chipping or hacking will not generally be approved. Before placing fresh concrete against a construction joint all loose material shall be removed and the surface sluiced with water until it is perfectly clean, thereafter all ponded water should be removed.

When concreting is to be resumed on a surface which has not fully hardened, all laitance shall be removed by wire brushing, the surface wetted, free water removed and a coat of cement slurry applied. On this, a layer of concrete not exceeding 150 mm thickness shall be placed and well rammed against the old work. Thereafter work shall proceed in the normal way.

4.18 Movement Joints

1. Movement joints are defined as all joints intended to accommodate relative movement between adjoining parts of a structure, special provision being made where necessary for maintaining the water tightness of the joint. The contractor shall comply with the instructions

of manufacturers of proprietary jointing materials and shall, if required by the Engineer, demonstrate that the jointing materials can be applied satisfactorily.

2. The surface of set concrete in a movement joint shall, as shown on the drawings, be painted with two coats of bituminous paint and new concrete shall be placed against it only when the paint is dry. Expansion joints shall be formed by a separating strip of approved preformed joint filler.
3. 3. Caulking grooves shall be provided. At all joints where a caulking groove is formed, immediately prior to caulking, the groove shall be wire brushed and loose material removed and blown out by compressed air. After the groove has dried, it shall be primed and caulked with approved sealing compound applied in accordance with the manufacturer's instructions. At all caulked joints, the face of the caulking strip and a width of concrete on either side shall be painted with two coats of paint having the same base as the sealing compound.

4.19 Foundation Bedding

All earth surfaces upon which or against which concrete is to be placed, shall be well compacted and free from standing water, mud or debris. Soft or spongy areas shall be cleaned out and back filled with either soil-cement mixture, lean concrete or clean sand compacted as approved by the Engineer. The surfaces of absorptive soils shall be moistened.

Concrete shall not be deposited on large sloping rock surfaces. The rock shall be cut to form rough steps or benches by picking, barring or wedging. The rock surface shall be kept wet for 2 to 4 hours before concreting.

4.20 Finishes

4.20.1 General

The formwork for concrete works shall be such as to give the finish as specified. The Contractor shall make good any unavoidable defects as approved consistent with the type of concrete and finish specified; defects due to bad workmanship (e.g. damaged or misaligned forms, defective or poorly compacted concrete) will not be accepted. The Contractor shall construct the formwork using the correct materials and to meet the requirements of the design and to produce finished concrete to required dimensions, plumbs, planes and finishes.

4.20.2 Surface Finish Type F1

The main requirement is that of dense, well compacted concrete. No treatment is required except repair of defective areas, filling all form tie holes and cleaning up of loose or adhering debris. For surfaces below grade which will receive waterproofing treatment the concrete shall be free of surface irregularities which would interfere with proper and effective application of waterproofing material specified for use.

4.20.3 Surface Finish Type F2

The appearance shall be that of a smooth dense, well- compacted concrete showing the slight marks of well fitted shuttering joints. The Contractor shall make good any blemishes.

4.20.4 Surface Finish Type F3

This finish shall give an appearance of smooth, dense, well-compacted concrete with no shutter marks, stain free and with no discolouration, blemishes, arises, airholes etc. Only lined or coated plywood with very tight joints shall be used to achieve this finish. The panel size shall be uniform and as large as practicable. Any minor blemishes that might occur shall be made good by the Contractor.

4.20.5 Unformed Surfaces

Finishes to unformed surfaces of concrete shall be classified as U1, U2, and U3, 'spaded or bonded concrete'. Where the class of finish is not specified the concrete shall be finished to Class U1.

Class U1 finish is the first stage for Class U2 and U3 finishes and for a bonded concrete surface. Class U1 finish shall be a levelled and screeded, uniform plain or ridged finish which (unless it is being converted to Class U2, U3, or bonded concrete) shall not be disturbed in any way after the initial set and during the period of curing, surplus concrete being struck off immediately after compaction.

Where a bonded concrete surface is specified, the laitance shall be removed from the Class U1 finished surface and the aggregate exposed while the concrete is still green.
A spaded finish shall be a surface free from voids and brought to a reasonably uniform appearance by the use of shovels as it is placed in the Works.

Class U2 finish shall be a wood float finish. Floating shall be done after the initial set of the concrete has taken place and the surface has hardened sufficiently. The concrete shall be worked no more than is necessary to produce a uniform surface free from screed marks.

Class U3 finish shall be a hard smooth steel-trowelled finish. Trowelling shall not commence until the moisture film has disappeared and the concrete has hardened sufficiently to prevent excess laitance from being worked into the surface. The surfaces shall be trowelled under firm pressure and left free from trowel marks.

The addition of dry cement, mortar or water shall not be permitted during any of the above operations.

4.20.6 Integral Cement Finish on Concrete Floor

In all cases where integral cement finish on a concrete floor has been specified, the top layer of concrete shall be screeded off to proper level and tamped with tamper so that the aggregate shall be forced below the surface. The surface shall be finished with a wooden float and a trowel with pressure. The finish shall be continued till the concrete reaches its initial set. No cement or cement mortar finish shall be provided on the surface. Where specified, a floor hardener as approved by the Engineer shall be supplied and used as recommended by the manufacturer.

4.21 Repair and Replacement of Unsatisfactory Concrete

Immediately after the shuttering is removed, all the defective areas such as honey-combed surfaces, rough patches, and holes left by form bolts etc. shall be inspected by the Engineer who may permit patching of the defective areas or reject the concrete work.

All through holes for shuttering shall be filled for full depth and neatly plugged flush with surface.

Rejected concrete shall be removed and replaced by the Contractor at no additional cost to the Employer.

For patching of defective areas all loose materials shall be removed, and the surface shall be prepared as approved by the Engineer.

Bonding between hardened and fresh concrete shall be done either by placing cement mortar with approved bonding agent or by applying epoxy. The decision of the Engineer as to the method of repairs to be adopted shall be final and binding on the Contractor. The surface shall be saturated with water for 24 hours before patching is done with 1:5 cement sand mortar. The use of epoxy for bonding fresh concrete shall be carried out as approved by the Engineer.

All the form bolt repairs and delayed repairs shall be carried out using a proportion of white cement in repair mix to the approval of the Engineer, so as to match the colour of the surrounding area.

4.22 Vacuum Dewatering of Slabs

Where specified floor slabs, either grade or suspended, shall be finished by vacuum dewatering including all operations such as poker vibration, surface vibration, vacuum processing, floating and trowelling as per equipment manufacturers recommendation. The equipment to be used shall be subject to the Engineer's approval.

4.23 Hot Weather Requirements

Concreting during hot weather shall be carried out as per IS: 7861 (Part I).

Adequate provisions shall be made to lower concrete temperatures which shall not exceed 33^{o} C at the time of placement of fresh concrete.

Where directed by the Engineer, the Contractor shall spray non-wax based curing compound on unformed concrete surfaces at no extra costs.

4.24 Liquid Retaining Structures

The Contractor shall take special care for concrete for liquid retaining structures, underground structures and those others specifically called for to guarantee the finish and water tightness.

The minimum level of surface finish for liquid retaining structures shall be Type F2. All such structures shall be hydro-tested.

The Contractor shall make all arrangements for hydro-testing of structure, all arrangements for testing such as temporary bulk heads, pressure gauges, pumps, pipe lines etc.

Any temporary arrangements that may have to be made to ensure stability of the structures shall also be considered to have been taken into account while quoting the rates.

Any leakage that may occur during the hydro-test or subsequently during the defects liability period or the period for which the structure is guaranteed shall be effectively stopped either by cement/epoxy pressure grouting, guniting or such other methods as may be approved by the Engineer. All such rectification shall be done by the Contractor to the entire satisfaction of the Employer/Engineer at no extra cost to the Employer.

4.25 Testing Concrete Structures for Leakage

Hydro-static test for water tightness shall be done at full storage level or soffit of cover slab, as may be directed by the Engineer, as described below:

In case of structures whose external faces are exposed, such as elevated tanks, the requirements of the test shall be deemed to be satisfied if the external faces show no sign of leakage or sweating and remain completely dry during the period of observation of seven days after allowing a seven day period for absorption after filling with water.

In the case of structures whose external faces are buried and are not accessible for inspection, such as underground tanks, the structures shall be filled with water and after the expiry of seven days after the filling; the level of the surface of the water shall be recorded. The level of water shall be recorded again at subsequent intervals of 24 hrs. over a period of seven days. Backfilling shall be withheld till the tanks are tested. The total drop in surface level over a period for seven days shall be taken as an

indication of the water tightness of the structure. The Engineer shall decide on the actual permissible nature of this drop in the surface level, taking into account whether the structures are open or closed and the corresponding effect it has on evaporation losses. Unless specified otherwise, a structure whose top is covered shall be deemed to be water tight if the total drop in the surface level over a period of seven days does not exceed 40 mm.

Each compartment/segment of the structure shall be tested individually.
For structures such as pipes, tunnels etc. the hydrostatic test shall be carried out by filling with water, after curing as specified, and subjecting to the specified test pressure for specified period. If during this period the loss of water does not exceed the equivalent of the specified rate, the structure shall be considered to have successfully passed the test.

4.26 Optional Tests

If the Engineer is not satisfied with the results of the tests under Clause 4.5 or otherwise considers that the materials i.e. cement, sand, coarse aggregates, reinforcement and water are not in accordance with the Specifications or if specified concrete strengths are not obtained, he may order tests to be carried out on these materials in laboratory, to be approved by the Engineer, as per relevant IS Codes. Contractor shall have to pay for these tests.

In the event of any work being suspected of faulty material or workmanship requiring its removal or if the works cubes do not give the stipulated strengths, the Engineer reserves the right to order the Contractor to take out cores and conduct tests on them or do ultrasonic testing or load testing of structure, etc. The Engineer also reserves the right to ask the Contractor to dismantle and re-do such unacceptable work, at no cost to the Employer.

If the structure is certified as failed by Engineer, the cost of the test and subsequent dismantling/reconstruction shall be borne by the Contractor.

The quoted unit rates/prices of concrete shall be deemed to provide for all tests mentioned above.

4.27 Acceptance Criteria

Any concrete work shall satisfy the requirements given below individually and collectively for it to be acceptable.

a) Properties of constituent materials;
b) Characteristic compressive strength;
c) Specified mix proportions;
d) Minimum cement content;
e) Maximum free-water/cement ratio;
f) Workability
g) Temperature of fresh concrete;
h) Density of fully compacted concrete;
i) Cover to embedded steel;
j) Curing;
k) Tolerances in dimensions;
l) Tolerances in levels;
m) Durability;
n) Surface finishes;
o) Special requirements such as;
    i) Water tightness
    ii) Resistance to aggressive chemicals
    iii) Resistance to freezing and thawing
    iv) Very high strength
    v) Improved fire resistance
    vi) Wear resistance

vii) Resistance to early thermal cracking

The Engineer's decision as to the acceptability or otherwise of any concrete work shall be final and binding on the Contractor.

For work not accepted, the Engineer may review and decide whether remedial measures are feasible so as to render the work acceptable. The Engineer shall in that case direct the Contractor to undertake and execute the remedial measures. These shall be expeditiously and effectively implemented by the Contractor. Nothing extra shall become payable to the Contractor by the Employer for executing the remedial measures.

4.28 Mode of Measurement and Payment

The unit rate for concrete work under various categories shall be all inclusive and no claims for extra payment on account of such items as leaving holes, embedding inserts, etc. shall be entertained unless separately provided for in the Schedule of Quantities. No extra claim shall also be entertained due to change in the number, position and/or dimensions of holes, slots or openings, sleeves, inserts or on account of any increased lift, lead of scaffolding etc. All these factors should be taken into consideration while quoting the unit rates. Unless provided for in the Schedule of Quantities the rates shall also include fixing inserts in all concrete work, whenever required.

Payments for concrete will be made on the basis of unit rates quoted for the respective items in the Schedule of Quantities. No deduction in the concrete quantity will be made for reinforcements, inserts etc. and opening less than 0.100 of a sq.m. and 0.010 cu.m where concrete is measured in cu.metres. Where no such deduction for concrete is made, payment for shuttering work provided for such holes, pockets, etc. will not be made. Similarly the unit rates for concrete work shall be inclusive or exclusive of shuttering as provided for in the Schedule of Quantities.

Payment for beams will be made for the quantity based on the depth being reckoned from the underside of the slabs and length measured as the clear distance between supports. Payment for columns shall be made for the quantity based on height reckoned upto the underside of slabs/beams.

The unit rate for precast concrete members shall include formwork, mouldings, finishing, hoisting and setting in position including setting mortar, provision of lifting arrangement etc. complete. Reinforcement and inserts shall be measured and paid for separately under respective item rates.

Only the actual quantity of steel embedded in concrete including laps as shown on drawings or as approved by Engineer shall be measured and paid for, irrespective of the level or height at which the work is done. The unit rate for reinforcement shall include all wastages, binding wires, chairs, spacer bars etc. For which no separate payment shall be made.

Where the formwork is paid for separately, it shall be very clearly understood the payment for formwork is inclusive of formwork, shuttering, shoring, propping scaffolding etc. Only the net area of concrete formed (shuttered) shall be measured for payment.

4.29 Waterstops

4.29.1 Material

The material for the PVC waterstops shall be a plastic compound with the basic resin of polyvinyl chloride and additional resins, plasticizers, inhibitors, which satisfies the performance characteristics specified below as per IS:12200. Testing shall be in accordance with IS: 8543.

a) Tensile strength : 11.6 N/mm^2 minimum
b) Ultimate elongation : 300% minimum
c) Tear resistance : 4.9 N/mm^2 minimum

d)	Stiffness in flexure	:	2.46 N/mm^2 minimum
e)	Accelerated extraction		
	i) Tensile strength	:	10.50 N/mm^2 minimum
	ii) Ultimate elongation	:	250% minimum
(f)	Effect of Alkali	:	7 days
	i) Weight increase	:	0.10% maximum
	ii Weight decrease	:	0.10% maximum
	iii) Hardness change	:	± 5 points
(g)	Effect of Alkali	:	28 days
	i) Weight increase	:	0.40% maximum
	ii) Weight decrease	:	0.30% maximum
	iii) Dimension change	:	±1%

PVC water stops shall be either of the bar type, serrated with centre bulb and end grips for use within the concrete elements or of the surface (kicker) type for external use.

Flexible water stops shall be fully supported in the formwork, free of nails and clear of reinforcement and other fixtures. Damaged water stops shall be replaced and during concreting care shall be taken to place the concrete so that water stops do not bend or distort.

PVC water stops shall be of approved manufacture. Samples and the test certificate shall be got approved by the Engineer before procurement for incorporation in the works.

4.29.2 Workmanship

Waterstops shall be cleaned before placing them in position Oil or grease shall be removed thoroughly using water and suitable detergents.

Waterstops shall be procured in long lengths as manufactured to avoid joints as far as possible. Standard L or T type of intersection pieces shall be procured for use depending on their requirement. Any non-standard junctions shall be made by cutting the pieces to profile for jointing. Lapping of waterstops shall not be permitted. All jointing shall be of fusion welded type as per manufacturer's instructions.

Waterstops shall be placed at the correct location/level and suitably supported at intervals with the reinforcement to ensure that it does not deviate from its intended position during concreting and vibrating. Particular care shall also be taken to ensure that no honey-combing occurs because of the serrations/end grips. Projecting portions of the waterstops embedded in concrete shall be thoroughly cleaned of all mortar/ concrete coating before resuming further concreting operations. The projecting waterstop shall also be suitably supported at intervals with the reinforcement to maintain its intended position during concreting so as to ensure that it does not bend leading to formation of pockets.

4.29.3 Measurement

Measurement shall be in running metres correct to two places of decimal. No separate payment shall be made for joints or intersection pieces.

4.30 Curing, Protecting, Repairing and Finishing

4.30.1 Curing

All concrete shall be cured by keeping it continuously damp for the period of time required for complete hydration and hardening to take place. Preference shall be given to the use of continuous sprays, or ponded water, continuously saturated coverings of sacking, canvas, hessain or other absorbent materials, or approved effective curing compounds applied with spraying equipment capable of producing a smooth, even textured coat. Extra precautions shall be exercised in curing

concrete during cold and hot weather as outlined hereinafter. The quality of curing water shall be the same as that used for mixing concrete.

4.30.1.1 Curing with Water

Fresh concrete shall be kept continuously wet for a minimum period of 10 days from the date of placing of concrete, following a lapse of 12 to 14 hours after laying of concrete. The curing of horizontal surfaces exposed to the drying winds shall however begin as soon as the concrete has hardened. Water shall be applied to formed surfaces immediately upon removal of forms. Quantity of water applied shall be controlled so as to prevent erosion of freshly placed concrete.

4.30.1.2 Continuous Spraying

Curing shall be assured by use of an ample water supply under pressure in pipes, with all necessary appliances of hose, sprinklers and spraying devices. Continuous fine mist spraying or sprinkling shall be used, unless otherwise specified or approved by the Engineer.

4.30.1.3 Alternate Curing Methods

Whenever in the judgment of the Engineer, it is necessary to omit the continuous spray method, a covering of clean sand or other approved means such as wet gunny bags, which will prevent loss of moisture from the concrete, may be used. No type of covering will be approved which would stain or damage the concrete during or after the curing period. Covering shall be kept continuously wet during curing period. For curing of concrete in sidewalks, floors, flat roofs of other level surfaces, the ponding method of curing is preferred. The method of containing the ponded water shall be approved by the Engineer. Special attention shall be given to edges and corners of the slabs to ensure proper protection to these areas. The ponded areas shall be kept continuously filled with water during the curing period.

4.30.1.4 Curing Compound

Surface coating type-curing compounds shall be used only by special permission of Engineer. Curing compounds shall be liquid type white pigmented, confirming to US Bureau of Reclamation specification. No curing compound shall be used on surfaces where future blending with concrete, water of acid proof membrane or painting is specified.

4.30.1.5 Curing Equipment

All equipment and materials required for curing shall be on hand and ready for use before concrete is placed.

4.30.2 `Protecting Fresh Concrete

Fresh concrete shall be protected from defacements and damage due to construction operations by leaving forms in place for an ample period. Newly placed concrete shall be protected by approved means such as tarpaulins from rain, sun and winds. Steps as approved by the Engineers hall also be taken to protect immature concrete from damage by debris, excessive lading, vibration, abrasion or contact with other materials, etc. that may impair the strength and/or durability of the concrete. Workmen shall be warned against and prevented from disturbing green concrete during its setting period. If it is necessary that the workmen enter the area of freshly placed concrete, the Engineer may require that bridges be placed over the area.

4.30.3 Repair and Replacement of Unsatisfactory Concrete

4.30.3.1 General

Immediately after the shuttering is removed, the surface of concrete shall be very carefully inspected and all defective areas attended to by the Engineer may permit patching of the defective areas or reject the concrete unit either partially or entirely. Rejected concrete shall be removed and replaced by the contractor. Holes shall be filled with mortar composed of one part of cement to one and half parts of sand passing 2.36 mm IS sieve after removing any loose stones adhering to the concrete. Concrete surfaces shall be finished as described in specifications or as directed by the Engineer. Superficial honey combed surfaces and rough patches shall be similarly made good immediately after removal of shuttering, in the presence of the Engineer and superficial water and air holes shall be filled in. The mortar shall be well worked into the surface with a wooden float. Excess water shall be avoided. Unless instructed otherwise by the Engineer, the surface of the exposed concrete placed against shuttering shall be rubbed down immediately on removal of shuttering to remove fine or other irregularities, care being taken to avoid damaging the surface. Surface irregularities shall be removed by grinding. If reinforcement is exposed or the honeycombing occurs at vulnerable positions e.g. ends of beams or columns, it may be necessary to cut out the member completely or in part and reconstruct. The decision of the Engineer shall be final in this regard. If only patching is necessary, the edges being cut perpendicular to the affected surface or with a small undercut if possible. Anchors, tees or dovetail slots shall be provided whenever necessary to attach the new concrete securely in place. An area extending several centimeters beyond the edges and the surfaces of the prepared voids shall be saturated with water for 24 hours immediately before the patching material is placed.

4.30.3.2 Use of Epoxy

The use of epoxy for bonding fresh concrete used for repairs will be permitted upon written approval of the Engineer. Epoxies shall be applied in strict accordance with the instructions of the manufacturer.

4.30.3.3 Method of Repair

Small size holes having surface dimensions about equal to the depth of the hole, holes left after removal of form bolts, grout insert holes and slots cut for repair of cracks shall be repaired as follows.

The hole to be patched shall be roughened and thoroughly soaked with clean water until absorption stops. A 5 mm thick layer of grout of equal parts of cement and sand shall be well brushed into the surface to be patched, followed immediately by the patching concrete which shall be well consolidated with a wooden float and left slightly protrude of the surrounding surface. The concrete patch shall be built up in 10 mm thick layers, after an hour or more, depending upon weather conditions, it shall be worked off flush with a wooden float and a smooth finish obtained by wiping with hessian. A steel trowel shall be used for this purpose. The mix for patching shall be of the same materials and in the same proportion as that used in the concrete being repaired, although some reduction in the maximum size of the coarse aggregates may be necessary and the mix shall be kept as dry as possible. Mortar filling by air pressure (gunniting) shall be used for repair of areas too large and/or too shallow for patching with mortar. Patched surfaces shall be given a final treatment to match the colour and texture of the surrounding concrete. White cement shall be substituted for ordinary cement, if so directed by the Engineer, to match the shade of the patch with the original concrete.

4.30.4 Curing of Patched Work

The patched area shall be covered immediately with an approved non-staining, water-saturated material such as gunny bags which shall be kept continuously wet and protected against sun and

wind for a period of 24 hours. Thereafter, the patched area shall be kept wet continuously by a fine spray or sprinkling for not less than 10 days. All fillings shall be tightly bounded to the concrete and shall be sound, free from shrinkage cracks after the fillings have been cured and dried.

4.31 Approval by the Engineer

All materials, procedures and operations used in the repair work shall be subject to the approval of the Engineer.

4.32 Precast Concrete

4.32.1 General

Precast concrete units, whether manufactured on or off site, shall comply in every way with the provisions of the contract for in situ concrete. Wherever possible, precast units shall be hydraulically pressed. When ready for incorporation in the works, precast units shall be responsible for the accuracy of the level, shape of the bed or platform. A suitable serial number and the date of casting shall be impressed or painted on each unit.

4.32.2 Striking Forms

Side shutters shall not be struck in less than 24 hours after depositing concrete and no precast unit shall be lifted until the concrete reaches strength of at least twice the stress to which the concrete may be subjected to at the time of lifting.

4.32.3 Precast Units

The lifting and removal of precast units shall be undertaken without causing shock, vibration or undue bending stresses to or in the units. Before lifting and removal takes place, contractor shall satisfy the Engineer or his representative that the methods he proposes to adopt for these operations will not over-stress or otherwise effect seriously the strength of the precast units. The reinforced side of the units shall be distinctly marked.

4.32.4 Curing

All precast work shall be protected from the direct rays of the sun for at least 7 days after casting and during that period each unit shall be kept constantly watered or preferably be completely immersed in water if the size of the unit so permits.

4.33 Slots, Openings, etc.

4.33.1 General

Slots, openings or holes, pockets, etc., shall be provided in the concrete work in the approved positions or as directed by Engineer. Short pipes with puddle collar shall be fixed in the sidewall of suction pipes. They shall be supplied at the appropriate time during construction. Any deviation from the approved drawings shall be made good by contractor at own expense, without damaging any other work. Sleeves, bolts, inserts etc., shall also be provided in concrete work where so required.

4.34 Grouting

4.34.1 Standard Grout

Grout shall be provided as specified on the drawings. The proportion of Standard Grout shall be such as to produce a flowable mixture consistent with minimum water content and shrinkage. Surfaces to be grouted shall be thoroughly roughened and cleaned. All Structural steel elements to be grouted shall be cleaned of oil, grease, dirt etc. The use of hot, strong caustic solution for this purpose will be permitted. Prior to grouting, the hardened concrete shall be saturated with water and just before grouting water in all pockets shall be removed. Grouting once started shall be done quickly and

continuously. Variation in grout mixes and procedures shall be permitted if approved by Engineer. The grout proportions shall be limited as follows:

Use	Grout Thickness	Mix Proportions	W/C Ratio (max)
a) Fluid mix	Under 25mm	One part Portland Cement to one part sand	0.4
b) General mix	25mm and over but less than 50mm	One part Portland Cement to 2 parts of sand	0.53
c) Stiff mix	50mm and over	One part Portland Cement to 3 parts of sand	0.53

4.34.2 Non-Shrinking Grout for Equipment Foundation

Non-shrinking grout shall be used for grouting of machine base plates, anchor bolts, other anchoring devices and at locations where ordinary grouts are ineffective due to shrinkage. It shall be composed of a type of expansive hydraulic sheeting binder and select-graded aggregates. It shall have properties as per "*Table 11: Proportions for Non-Shrinking Grout*".

Table 11: Proportions for Non-Shrinking Grout

S. No.	Properties	Values
1	Maximum grain size	6 mm
2	Water % (for 80% flow)	15.17
3	Density of hardened grout	2.27 – 2.30 gm/m
4	Compressive strength N/sqmm	
	Minimum 3 days	23
	7 days	34

Mixing, batching, cleaning, preparation of surface and curing of non-shrinking grout shall be done as per manufacturer's instructions.

4.35 Inspection

a. All materials, workmanship and finished construction shall be subject to continuous inspection and approval of the Engineer.
b. All materials supplied by the Contractor and all work or construction performed by the Contractor which is rejected as not being in conformity with the specifications and requirements, shall be immediately replaced.
c. All concrete shall be protected against damage until final acceptance by the Engineer.

4.36 Clean-up

a. Upon completion of the concrete work, all forms, equipment, construction tools, protective coverings and any debris resulting from the work shall be removed from the premises.
b. All debris i.e. empty containers, scrap wood, etc., shall be removed to "dump" daily, or as directed by the Engineer.
c. The finished concrete surfaces shall be left in a clean condition satisfactory to the Engineer.

4.37 Preformed Fillers and Joint Sealing Compound

4.37.1 Materials

Preformed filler for expansion/isolation joints shall be non-extruding and resilient type of bitumen impregnated fibres conforming to IS: 1838 (Part I).
Bitumen coat to concrete/masonry surfaces for fixing the preformed bitumen filler strip shall conform to IS: 702. Bitumen primer shall conform to IS: 3384.

Sealants shall be of the following types:

4.37.1.1 Sealant Type A

Sealant Type A shall be a gun grade, non-slumping compound suitable for sealing horizontal, vertical and soffit joints in water retaining structures. It shall be a UK WFBS material approved for unrestricted use in contact with potable water to the full exposure condition of 15000 mm^2/l, and shall not support bacterial growth.
It shall be stable and shall have a low water absorption and good adhesion to concrete.
Hardness (Shore A) : > 12
Transverse Movement Accommodation : ±15%

4.37.1.2 Sealant Type B

Sealant type shall be a gun grade compound, suitable for sealing vertical movement and construction joints in concrete structures. It shall be flexible, resistant to aging, physical damage and weathering and shall have good adhesion to concrete.
Hardness (Shore A) : > 12
Transverse Movement Accommodation : ±12.5%

4.37.1.3 Sealant Type C

Sealant type C shall be similar to Type B above. In addition it shall have been designed for sealing movement and construction joints in hydraulic and water retaining structures and shall be suitable for use in contact with potable water.
Hardness (Shore A) : > 20
Transverse Movement Accommodation : ±12.5%

4.37.1.4 Sealant Type D

Sealant Type D shall be a pourable compound suitable for sealing horizontal movement and construction joints in concrete structures. It shall be flexible, resistant to aging, physical damage and weathering and shall have good adhesion to concrete.
Hardness (Shore A) : > 9
Transverse Movement Accommodation : ±12.5%

4.37.1.5 Sealant Type E

Sealant Type E shall be a cold pouring compound complying with BS 5212, suitable for sealing movement and construction joints in concrete paved areas. It shall be resistant to fuels, oils and hydraulic fluids. It shall be tough, abrasion-resistant and shall not decompose in strong sunlight.
Hardness (Shore A) : > 12
Transverse Movement Accommodation : ±12.5%

4.37.1.6 Approved Sealants

The following approved sealants meet the above specifications.
Sealant Type A, B and C : Thioflex 600 gun grade

Sealant Type	:	Thioflex 600 pourable grade
Sealant Type E	:	Colpor 200

The hardness value specified in the above summaries is the Shore A Durometer value at 14 days at 25^{o} C and 50% RH. The specified transverse movement values are based on joints having a width to depth ratio of 1.5: 1.

The Contractor may use the above sealants or ones meeting equivalent or higher specifications.

4.37.2 Workmanship

The thickness of the preformed bitumen filler shall be 25mm for expansion joints and 50mm for isolation joints around foundation supporting rotatory equipments. Contractor shall procure the strips of the desired thickness and width in lengths as manufactured. Assembly of small pieces/thicknesses of strips to make up the specified size shall not be permitted.

The concrete/masonry surface shall be cleaned free from dust and any loose particles. When the surface is dry, one coat of industrial blown type bitumen of grade 85/25 conforming to IS:702 shall be applied hot by brushing at the rate of 1.20 kg/sq.m. When the bitumen is still hot the preformed bitumen filler shall be pressed and held in position till it completely adheres. The surface of the filler against which further concreting/masonry work is to be done shall similarly be applied with one coat of hot bitumen at the rate of 1.20 kg/sq.m.

Sealing compound shall be heated to a pouring consistency for enabling it to run molten in a uniform manner into the joint. Before pouring the sealing compound, the vertical faces of the concrete joint shall be applied hot with a coat of bitumen primer conforming to IS:3384 in order to improve the adhesive quality of the sealing compound.

Expansion joints between beams/slabs shall be provided with 100mm wide x 4mm thick mild steel plate at the soffit of RCC beams/slabs to support and prevent the preformed joint filler from dislodging. This plate shall be welded to an edge angle of ISA 50 x 50 x 6mm provided at the bottom corner, adjacent to the expansion joint of one of the beams/slabs, by intermittent fillet welding. Steel surfaces shall be provided with 2 coats of red oxide zinc chrome primer and 3 coats of synthetic enamel paint finish.

The Contractor shall construct recesses at all joints and on both faces of the concrete work except on the underside of ground slabs. The recesses shall be accurately formed to the lines and dimensions shown on the Drawings or as agreed with the Engineer.

The Contractor shall prepare the surfaces of the recess and shall supply a joint sealer and fill or caulk the recess completely with it.

Joint sealing shall not be commenced without the approval of the Engineer. In reservoir joints the sealer shall be poured after completion of the water tightness test, to the satisfaction of the Engineer.

All joint sealers shall be from an approved manufacturer. The Contractor shall supply the manufacturer's test certificates for each consignment of each type of joint sealant delivered to the Site and shall if requested supply to the Engineer sufficient samples of each type and consignment for confirmatory tests to be carried out in accordance with the appropriate test procedure.

Sealants shall be installed in strict accordance with the manufacturer's instructions. De-bonding strip shall be used in conjunction with the sealers as indicated on the Drawings. The de-bonding strip shall be compatible with the joint sealer and shall be resistant to attach from the primer used to bond the sealer to the concrete.

Polysulphide and polyurethane sealants shall not abut bitumen sealers. Surfaces to receive Polysulphide and polyurethane sealants shall be kept free from bituminous paints. All sealants shall be appropriate for the prevailing climatic conditions. Bituminous sealants shall comply with the BS 2499 for Type A1. Polysulphide sealants shall comply with IS 12118.

4.37.3 Measurement

Measurement for the preformed joint filler shall be in sq.m correct to two places of decimal for the specified thickness as per items of work. Measurement for applying the bitumen coat to concrete/masonry surfaces shall be in sq.m correct to two places of decimal. Measurement for the joint sealing compound shall be in running metres correct to two places of decimal for the specified width and thickness as per the items of work. Measurement for the mild steel corner angle and plate shall be by weight as per the items of work.

4.38 Concreting Records

A written record of the concrete works shall be made each day by the Contractor and kept available for inspection by the Engineer. The diary shall contain notes and records of:

(a) The names of the Contractor's Engineer who are responsible for the different phases of the concrete work and also the names of their assistants.

(b) The temperatures of air, water, cement, aggregate, together with the air humidity and type of weather.

(c) Deliveries to the Site of concrete materials (quantity, brand of concrete, etc).

(d) Inspections carried out, tests performed, etc. and their results.

(e) Times of commencement and completion of different parts of the concrete works and times of erection and striking of forms.

(f) Quantity of cement, fine and coarse aggregate and admixture used for each section of work and the number and kind of test samples taken on these ingredients and water.

CONCRETE POUR CARD

CLIENT : DATE : POUR NO. :

PROJECT : STRUCTURE :

Contractor : MAX. AGGREGATE SIZE/ SLUMP :

START / COMPLETION TIME : /

DRG. NO. :

MIXING TIME :

CONCRETE GRADE / QUANTITY : /

SL. NO.	ITEM			Contractor's Rep. Sign	Engineer's Sign	Remarks
1.	BEFORE CONCRETING	CENTRELINES CHECKED				POUR AUTHORISED SITE ENGINEER
2.		FORMWORK AND STAGING CHECKED FOR ACCURACY, STRENGTH & FINISH				
3.		REINFORCEMENT CHECKED				
4.		COVER TO REINFORCEMENT CHECKED				
5.		VERIFIED TEST CERTIFICATE FOR CEMENT/STEEL		YES / NO	YES / NO	
6.		ADEQUACY OF MATERIALS / EQUIPMENT FOR POUR		YES / NO	YES / NO	
7.		EMBEDDED PART S	CIVIL			

		CHECKED	MECHANICAL			
		(LOCATION & PLUMB)	ELECTRICAL			
8.	SOFFIT(S) & POUR TOP(T) LEVELS CHECKED BEFORE (B) & AFTER (A) FORM REMOVAL (ONLY OF BEAMS OF OVER 10 M SPAN & IMPORTANT STRUCTURE LIKE T.G. ETC.)	S(B) T(B) S(A) T(A)				
9.	CONSTRUCTION JOINTS LOCATION & TIME (IF NOT AS PER DRAWING)					
10.	CEMENT CONSUMPTION IN KGS.					
11.	NUMBER OF CUBES AND IDENTIFICATION MARKS					
12.	TEST CUBE RESULTS (7 DAYS / 28 DAYS)					
13.	CONCRETE CONDITION ON FORM REMOVAL	V.GOOD/GOOD/FAIR/POOR				

SITE-IN-CHARGE

NOTES : 1. EACH ITEM TO BE CHECKED AND SIGNED BY THE RESPECTIVE ENGINEERS.

2. ITEMS 8 TO 13 (BOTH INCLUSIVE) TO BE FILLED ONLY BY ENGINEER.

3. EACH POUR TO HAVE SEPARATE CARDS, IN TRIPLICATE ONE EACH FOR CLIENT, CONSULTANT & SITE OFFICE.

UNDER REMARKS INDICATE DEVIATIONS FROM DWGS. & SPECIFICATIONS, CONGESTION IN REINFORCEMENT IF ANY, UNUSUAL OCCURENCES, SUCH AS FAILURE OF EQUIPMENTS, SINKING OF SUPPORTS / PROPS. HEAVY RAINS AFFECTING CONCRETING, POOR COMPACTION, IMPROPER CURING, OTHER DEFICIENCIES, OBSERVATIONS ETC.

End of Chapter-4

CHAPTER 5

ROADS AND DRAINS

CHAPTER 5

ROADS AND DRAINS

5.1 Definitions

The words like Contract, Contractor, Engineer (synonymous with Engineer-in-charge), Drawings, Employer, Government, Works and Work Site used in these Specifications shall be considered to have the meaning as understood from the definitions of these terms given in the General Conditions of Contract.

The following abbreviations shall have the meaning as set forth below:

MORTH	:	Ministry of Road Transport and Highways
IRC	:	Indian Roads Congress
IS	:	Indian Standard published by the Bureau of Indian Standards
GSB	:	Granular Sub Base
WMM	:	Wet Mix Macadam
BM	:	Bituminous Macadam
BC	:	Bituminous Concrete
CBR	:	California Bearing Ratio
AASHTO	:	American Association of State Highway and Transportation Officials
ASTM	:	American Society for Testing and Materials
BS	:	British Standard published by the British Standards Institution

The various elements in the cross-section of a road (STP) referred to in these Specifications are shown in the cross-sections in **Fig. 5-1**.

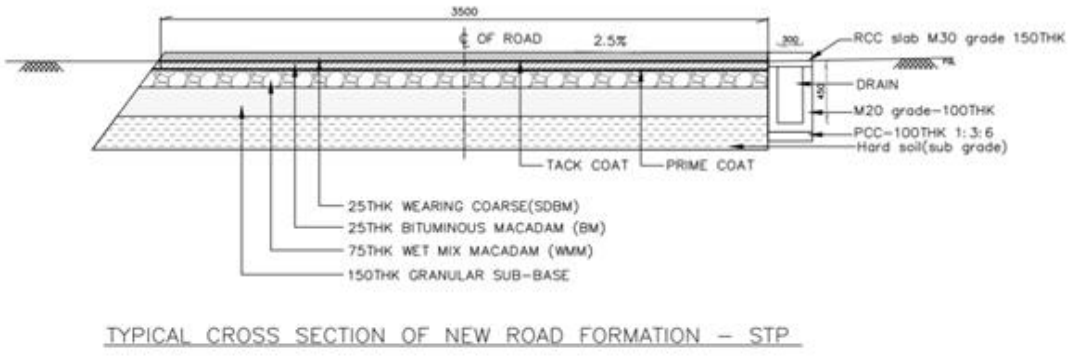

Fig. 5-1: Proposed Typical Cross Section of the Road (STP)

5.2 Applicable Codes and Specifications

The following specifications, standards and codes are referred to in this part.

IS : 460 (Parts 1 to 3) : Specification for Test sieves
IS : 1077 : Common burnt clay building bricks - Specification
IS : 1124 : Method of test for determination of water absorption, apparent specific gravity and porosity of natural building Aggregates / stones
IS : 1195 : Specification for Bitumen Mastic for Flooring
IS : 1196 : Code of Practice for Laying Bitumen Mastic Flooring
IS : 1834 : Specification for Hot Applied Sealing Compounds for Joints in Concrete
IS : 2386 (Parts 1 to 8) : Methods of test for aggregates for concrete
IS : 2720 (Part 5) : Method of Test for Soils for determination of Liquid and plastic limit.
IS : 6241 : Method of test for determination of stripping value of road aggregates.
IRC : 16 : Specification for priming of Base Course with Bituminous Primers.
IRC : 17 : Tentative specification for Single Coat Bituminous Surface Dressing
IRC : 19 : Standard specifications and code of practice for water bound macadam
IRC : 29 : Specification for bituminous concrete (Asphaltic Concrete) for road pavement.
MORTH Specifications : Ministry of Road Transport and Highways Specifications for Road and Bridge works
SECTION-100: GENERAL
SECTION-300 : EARTHWORK
SECTION-401 : GRANULAR SUB BASE
SECTION-406 : WET MIX MACADAM
SECTION-504 : BITUMINOUS MACADAM
SECTION-507 : BITUMINOUS CONCRETE

5.3 Road Configuration

The roads shall be installed in layers as per Drawing over the back fill as per concerned sections of MORTH. In Plant premise all the motorable road width is minimum 3.5m.
On laying of Pumping main/sewer lines in the trenches, the roads shall be restored to its original condition in layers as per Drawing over the back fill as per concerned sections of MORTH

Technical specification:

a) Backfill over the water lines / sewer lines to the desired level as per drawing and specification.
b) Approved soil compacted in layers as per drawing, using soil deposited at site from road cutting and excavation to achieve compaction level Table 300-2 and Section 301 of MORTH Technical specification.
c) Layer of sand / stone dust as per drawing to achieve 97% relative compaction of laboratory dry density to meet requirement of table 300-2 of MORTH specification.
d) Granular Sub base as per section 401 of MORTH specification.

e) Wet mix macadam (WMM) as per section 406 of MORTH specification.
f) Bituminous macadam (BM) as per section 504 of MORTH specification.
g) Bituminous concrete (BC) as per section 507 of MORTH specification.

5.4 Materials

5.4.1 General

All materials shall be obtained from local sources and shall conform to technical specifications and be subject to Engineer's approval prior to use.

5.4.2 Approved soil for Subgrade / Embankment

The materials used in embankments, subgrades and miscellaneous backfills shall be soil, moorum, gravel, a mixture of these or any other material approved by the Engineer. Such materials shall be free of logs, stumps, roots, rubbish or any other ingredient likely to deteriorate or affect the stability of the embankment/ subgrade.

The Contractor shall carry out the excavation in such a manner that the acceptable materials are excavated separately for use in backfill/restoration works without contamination by the unacceptable materials. The acceptable materials shall be stockpiled separately.

It shall be ensured that the subgrade material when compacted to the density requirements as in Table 5.1 (As per Table 300-2 of MORTH specification) shall yield the design CBR value of the subgrade.

Table 5.1: Compaction requirement for Subgrade
(As per Table 300-2 of MORTH Specification)

Type of work/material		**Relative compaction as % of max. lab dry density as per IS: 2720 (Part 8)**
1	Subgrade and earthen shoulders	Not less than 97
2	Embankment	Not less than 95

The Contractor shall at least 7 working days before commencement of compaction submit the following to the Engineer for approval:

i) The values of Maximum Dry Density and Optimum Moisture Content obtained in accordance with IS: 2720 (Part 7) or (Part 8), as the case may be, appropriate for each of the fill materials he intends to use.
ii) A graph of density plotted against moisture content from which each of the values in (i) above of maximum dry density and optimum moisture content were determined.
iii) The Dry density-moisture content - CBR relationships for light, intermediate and heavy compactive efforts (light corresponding to IS: 2720 (Part 7), heavy corresponding to IS: 2720 (Part 8) and intermediate in-between the two) for each of the fill materials he intends to use in the subgrade.

Once the above information has been approved by the Engineer, it shall form the basis for compaction.

5.4.3 Granular Sub Base

The material to be used for the work shall be natural sand, murum, gravel, crushed stone, or combination thereof depending upon the grading required. Materials like crushed slag, crushed concrete, brick metal and kankar may be allowed only with the specific approval of the Engineer. The material shall be free from organic or other deleterious constituents and conform to grading-iii given in **Table 5.2: Gradation for coarse graded granular Sub base.** (As per Table 400-1 of MORTH Specifications).

The CBR shall be determined at the density and moisture content likely to be developed in equilibrium conditions, which shall be taken as being the density relating to a uniform air, voids content of 5 per cent.

Table 5.2: Gradation for coarse graded granular Sub base.
(As per TABLE 400–1 of MORTH Specification)

IS Sieve	Percent by weight passing the IS Sieve		
Designation	**Grading I**	**Grading II**	**Grading III**
75.0 mm	100	-	-
53.0 mm	80-100	100	100
26.5 mm	55 - 90	70-100	55-75
9.50 mm	35-65	50-80	-
4.75 mm	25-55	40-65	10-30
2.36 mm	20-40	30-50	-
0.425 mm	10-15	10-15	-
0.075 mm	<5	<5	<5
CBR Value (Minimum)	30	25	20

Note: The material passing 425 micron (0.425 mm) sieve for all three gradings when tested according to IS : 2720 (Part 5) shall have a liquid limit and plasticity index not more than 25 and 6 per cent, respectively.

5.4.4 Coarse Aggregates

Coarse aggregate, stone chippings shall consist of natural or crushed stone, clean, hard, tough, durable and free from excess of flat, elongated, soft and disintegrated particles, dirt, salt, alkali, vegetable matter, adherent coatings, organic and other objectionable matter, and shall conform to the physical requirements given in **Table 5.3** and **Table 5.4** hereunder, as applicable. Aggregate for bituminous wearing courses shall, in addition, have good hydrophobic properties, i.e., the ability to retain the film of bituminous material applied to the stone in all weather conditions, especially in wet conditions. Basalt and dolerite are good in this respect; granite and quartzite are comparatively poor.

Table–5.3: Physical	**Test**	**Requirements**	**Test Method**

Requirements of Coarse Aggregate for Wet Mix Macadam (WMM) Sl. No			
1.	Los Angeles Abrasion Value*	40 percent (max.)	IS:2386 (Part – IV)
	Or		
	Aggregate Impact Value*	30 percent (max.)	IS:2386 (Part – IV) Or IS:5640***
2.	Flakiness Index **	15 percent (max.)	IS:2386 (Part I)
3.	Combined Flakiness and Elongation Indices**	35 percent (max.)	IS:2386 (Part I)

(*) Aggregate may satisfy requirements of either of two tests.

(**) Requirements of flakiness index shall be enforced only in case of crushed broken stone.

(***) Aggregates like brick, metal, kankar, laterite etc., which get softened in presence of water shall be tested for impact value under wet conditions in accordance with IS: 5640.

Table – 5.4: Physical Requirements of Coarse Aggregates for Dense Bituminous macadam (BM) (As per Table 500-8 of MORTH Specification)

Sl.No.	**Test**	**Requirements**	**Test Method**
1.	Los Angeles Abrasion Value*	35 percent (max.)	IS:2386 (Part – IV)
	Or		
	Aggregate Impact Value*	27 percent (max.)	IS:2386 (Part –
2.	Combined Flakiness and Elongation Indices (Total) **	35 percent (max.)	IS:2386 (Part I)
3.	Coating and Stripping of Bitumen Aggregate Mix	Min. Retained coating 95%	IS:6241
4.	Water Absorption	2 percent (max.)	IS:2386 (Part-III)
5.	Soundness		
	Loss with Sodium Sulphate – 5 cycles	12 percent (max.)	IS:2386 (Part-V)
	Loss with Magnesium Sulphate – 5 cycles	18 percent (max.)	

(*) Aggregate may satisfy requirements of either of two tests

(**) Requirement of flakiness index shall be enforced only in case of crushed broken stone

5.4.5 Murum/Kankar/Gravel

Murum shall contain a low-plasticity binder material mixed with hard granular particles, such as sand and/or gravel. Murum shall be of sound and hard quality, unaffected by weather, and shall be screened at the quarry, free from all impurities. Large lumps shall all be broken at the quarry, and murum delivered at the site must pass through a 63 mm ring. Murum shall not contain more than 5% to 8% of fines passing a 75-micron sieve.

Gravel shall be composed of large, coarse, silicious grains, sharp and gritty to the touch, thoroughly free from dirt, organic and deleterious matter. It shall be hard, tough, dense, and shall not contain particles larger than 12 mm, nor more than 10 percent silt.

5.4.6 Sand / Stone Dust

The sand / Stone dust shall consist of clean, hard, strong and durable pieces of crushed stone, crushed gravel, or a suitable combination of natural sand, crushed stone or gravel. They shall not contain dust, lumps, soft or flaky, materials, mica or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attack the embedded steel. Motorized sand washing machines should be used to remove impurities from sand. Fine aggregate having a positive alkali-silica reaction shall not be used. All fine aggregates shall conform to IS: 383, and tests for conformity shall be carried out as per IS: 2386 (Parts I to VIII). The Contractor shall submit to the Engineer the entire information indicated in Appendix A of IS: 383. The fineness modulus of fine aggregate shall neither be less than 2.0 nor greater than 3.5. The Sand used shall be coarse, sharp, gritty, clean, granular material. Only material passing through a 4.75 mm sieve and retained on a 75-micron sieve shall be used.

The sand / Stone dust / fine aggregates shall conform to the grading requirement in Table 5.5

Table 5.5: Gradation requirement of Sand / Fine aggregates
(As per Table 1000-2 of MORTH Specifications)

IS Sieve Size	Per cent by Weight Passing the Sieve		
	Zone I	Zone II	Zone III
10 mm	100	100	100
4.75 mm	90-100	90-100	90-100
2.36 mm	60-95	75-100	85-100
1.18 mm	30-70	55-90	75-100
600 micron	15-34	35-59	60-79
300 micron	5-20	8-30	12-40
150 micron	0-10	0-10	0-10

Note: When the grading falls outside the limits of any particular grading zone of sieves, other than the 600-micron IS Sieve, by a total amount not exceeding 5 percent, it shall be regarded as falling within that grading zone. However, for crushed stone sand, the permissible limit on the 150-micron IS Sieve is increased to 20 percent. Reference shall be made to clause: 4.3 of IS: 383.

5.4.7 Bituminous Materials

Bituminous materials shall conform to IS: 73, IS: 215, IS: 217 or IS: 454 as applicable and be of the grade specified.

Table 5.6: Physical requirements of Coarse aggregates for Bituminous concrete (BC). (As per TABLE 500-16: MORTH specifications)

PROPERTY	TEST	SPECIFICATION	METHOD OF TEST
Cleanliness (dust)	Grain size analysis	Max 5% passing 0.075 mm sieve.	IS: 2386 Part I
Particle shape	Flakiness and Elongation Index	Max 30% (Combined) 2	IS: 2386 Part I
Strength	Los Angles Abrasion Value or Aggregate Impact Value	Max 30% Max 24%	IS: 2386 Part IV
Polishing	Polished Stone Value	Min 55	BS: 812-114
Durability	Soundness: Sodium Sulphate or Magnesium Sulphate	Max 12% Max 18%	IS: 2386 Part V
Water Absorption	Water absorption	Max 2%	IS: 2386 Part III
Stripping	Coating and Stripping of Bitumen Aggregate Mixtures	Minimum retained coating 95%.	IS: 6241
Water Sensitivity	Retained Tensile Strength*	Min 80%	AASHTO 283

* If the minimum retained Tensile strength test falls below 80%, use of anti-stripping agent is recommended to meet the requirement.

5.5 Earth work

5.5.1 Earthwork in Excavation

In general, the excavation shall be in accordance to Specifications specified elsewhere.

Profiles of road excavation shall be laid at 50 m intervals or as specified in the Drawings to conform to the required alignment, sections, grades, and side slopes, and the lines of cuts shall be clearly marked.

Contractor shall on no account excavate beyond the slopes or below the specified grade unless so approved by the Engineer in writing. If excavation is done below the specified level or outside the section the Contractor shall be required to fill up with approved materials, in layers of 150 to 200 mm, watered and compacted as specified for the subgrade.

The excavation shall be finished neatly, smoothly and evenly to the correct lines, grades, sections as shown in the drawings or approved by , and evenly to the correct lines, grades, and sections as shown in the drawings or approved by the Engineer.

5.5.2 Earthwork in Subgrade

The Subgrade shall be formed of approved soil excavated from road trenches and stacked separately.

Profiles of subgrade shall be set up with stout poles to mark the centre and edges of the formation with the top levels of formation clearly marked by paint or cut and the slopes with strings and pegs at every 10 metres on straight portions.

Subgrade material shall be placed in successive horizontal layers of 200 mm depth extending to the full width of the Subgrade/trench to allow compaction of the full specified section to 150 mm using mini rollers/tampers/plate vibrators till the soil is evenly compacted to 95% of Proctor density with 2% variation in optimum moisture content. Before placing the next layer of 200 mm, the surface of the underlayer shall be moistened and scarified with pick axes or spades to provide a satisfactory bond with the next layer. The next layer shall also be compacted to a depth of 150 mm across the full width of the trench section, until the soil is evenly compacted to 95% of the Proctor density, with a 2% variation in optimum moisture content.
When boulders, broken stones, and similar hard materials are mixed with the embankment materials, care shall be taken to ensure that they are distributed uniformly throughout the bank and that no hollows are left near them. No stone or hard material shall project above the top of any layer. Each layer of embankment shall be watered, levelled, and compacted as specified before the succeeding layer is placed. The surface of the embankment shall be maintained at all times during construction at a cross fall that sheds water and prevents ponding.

If the soil contains less than the optimum moisture, water shall be added to the loose layers of the subgrade to uniformly bring the moisture up to the required level. If the material contains more than the required moisture, it shall be allowed to dry until the moisture is reduced to the required extent. The moistured or dried loose layers shall be compacted using a vibratory roller or mini roller or plate vibrator or tampered to achieve a compaction level of 95% of the Proctor density.

5.6 Compaction with Sand/stone dust

To achieve better compaction and a compacted surface before laying the GSB layer, two layers of sand and stone dust shall be laid and compacted to a depth of 150 mm each.

5.7 Preparation of Granular Sub-base (GSB)

Spreading and Compacting: The granular sub base material of **grade-iii** as specified in **Table 5.2: Gradation for coarse graded granular Sub base** (As per Table 400–1 of MORTH Specifications) shall be spread on the prepared sub grade maintaining the required slope and grade during the operation or other means as approved by the Engineer or as per applicable MORTH Specifications. The work shall be done as per Clause 401 MORTH V revision and as per BOQ provisions.

When the subbase material consists of a combination of materials mentioned in clause 401.2, mixing shall be done mechanically by the mix-in-place method.

Manual mixing shall be permitted only where the width of laying is not adequate for mechanical operations, as in small – sized jobs. The equipment used for mix-in-place construction shall be rotavator or similar approved equipment capable of mixing the material to the desired degree. If so desired by the Engineer, trial runs with the equipment shall be carried out to establish its suitability for the work.

Moisture content of the loose material shall be checked in accordance with IS: 2720 (part 2) and suitably adjusted by sprinkling additional water from a truck mounted or trailer mounted water tank and suitable for applying water uniformly and at controlled quantities to variable widths of surface or other means approved by the Engineer so that, at the time of compaction, it is from 1 percent above to 2 percent below the optimum moisture content corresponding to IS: 2720 (part 8). While adding water, due allowance shall be made for evaporation losses. After water has been added, the material shall be processed by mechanical or other approved means like disc harrows, rotavators until the layer is uniformly wet.

Rolling shall be continued until the density achieved is at least 98 percent of the maximum dry density for the material, as determined in accordance with IS: 2720 (Part 8). The surface of any layer of material on completion of compaction shall be well closed, free from movement under compaction equipment and from compaction planes, ridges, cracks or loose material.
All loose, segregated, or otherwise defective areas shall be made good to the full thickness of the layer and re-compacted.

5.8 Wet mix Macadam Course (WMM)

The GSB layer surface over which Wet Mix Macadam (WMM) is to be laid shall be prepared to the specified grade and camber, and made free of dust and other extraneous materials.
Any ruts or soft, yielding areas shall be corrected in an approved manner and compacted until firm. WMM. sub-base course of specified thickness shall be provided. The course aggregate for this shall conform to requirements in **Table-5.7: Grading Requirements of Coarse Aggregates for Wet Mix Macadam (WMM)** (As per Table 400-13 of MORTH Specifications).

Table – 5.7: Grading Requirements of Coarse Aggregates for Wet Mix Macadam (WMM) (As per Table 400-13 of MORTH Specifications)

IS Sieve Designation	Percent by weight passing the IS sieve
53.00 mm	100
45.00 mm	95 – 100
26.50 mm	-
22.40 mm	60-80
11.20 mm	40-60
4.75 mm	25-40
2.36 mm	15-30
600.00 micron	8-22
75.00 micron	0-8

5.8.1 Preparation of WMM layer

Preparation of mix: Wet Mix Macadam shall be prepared in an approved mixing plant of suitable capacity having provision for controlled addition of water and forced/positive mixing arrangement like pugmill or pan type mixer of concrete batching plant. For small quantity of wet mix work, the Engineer may permit the mixing to be done in concrete mixers.

Optimum moisture for mixing shall be determined in accordance with IS: 2720 (Part-8) after replacing the aggregate fraction retained on 22.4 mm sieve with material of 4.75 mm to 22.4 mm size. While adding water, due allowance should be made for evaporation losses. However, at the time of compaction, water in the wet mix should not vary from the optimum value by more than agreed limits. The mixed material should be uniformly wet and no segregation should be permitted.

Spreading of mix: Immediately after mixing, the aggregates shall be spread uniformly and evenly upon the prepared subgrade /sub- base/base in required quantities. In no case should these be dumped in heaps directly on the area where these are to be laid nor shall their hauling over a partly completed stretch be permitted.

The mix may be spread either by a paver finisher or motor grader. For portions where mechanical means cannot be used, manual means as approved by the Engineer shall be used so as to achieve the specified slope and grade. The surface of the aggregate shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregate as may be required. The layer may be tested by depth blocks during construction. No segregation of larger and fine particles should be allowed. The aggregates as spread should be of uniform gradation with no pockets of fine materials.

Compaction: After the mix has been laid to the required thickness, grade and crossfall/camber the same shall be uniformly compacted, to the full depth with suitable vibratory roller. The speed of the roller shall not exceed 5 km/h. The work shall be done as per Clause 406 MORTH V revision and as per BOQ provisions.

5.9 Primer coat

Primer: The choice of a bituminous primer shall depend upon the porosity characteristics of the surface to be primed as classified in IRC: 16. Surface of low porosity; such as wet mix macadam. The primer shall be bitumen emulsion.

Primer viscosity: The type and viscosity of the primer shall comply with the requirements of IS 8887, as sampled and tested for bituminous primer in accordance with these standards. Guidance on viscosity and rate of spray is given in Table-5.8: Requirement of Viscosity and quantity of Liquid bituminous Primer (As per Table 500-1 of MORTH Specifications).

Table-5.8: Selection Criteria for Viscosity-Graded (VG) Paving Bitumens based on Climatic conditions (As per Table 500-1 of MORTH Specifications)

Lowest Daily Mean Air Temperature, °C	**Highest Daily Mean Air Temperature, °C**		
	Less than 20 °C	20 to 30 °C	More than 30 °C
More than -10 °C	VG-10	VG-20	VG-30
-10 °C or lower	VG-10	VG-10	VG-20

Providing and applying primer coat with S.S. bitumen emulsion on prepared surface of granular base such as WMM including cleaning of road surface and spraying primer at the rate of 0.60 kg/sqm using mechanical means complete as per specifications The work shall be done as per Clause 502 MORTH V revision and as per BOQ provisions.

Preparation of road surface: The surface to be primed shall be prepared in accordance with Clauses 501.8. and 902 as appropriate. Immediately prior to applying the primer the surface shall be carefully swept clean of dust and loose particles, care being taken not to disturb the interlocked aggregate. This is best achieved when the surface layer is slightly moist (lightly sprayed with water and the surface allowed to dry) and the surface should be kept moist until the primer is applied.

Application of bituminous primer: The viscosity and rate of application of the primer shall be as specified in the Contract, or as determined by site trials carried out as directed by the Engineer. The bituminous primer shall be sprayed uniformly in accordance with Clause 501 of MORTH specifications. The method for application of the primer will depend on the type of equipment to be used, size of nozzles, pressure at the spray bar and speed of forward movement. The Contractor shall demonstrate at a spraying trial, that the equipment and method to be used is capable of producing a uniform spray, within the tolerances specified.

Curing of primer and opening to traffic: A primed surface shall be allowed to cure for at least 24 hours or such other period as is found to be necessary to allow all the volatiles to evaporate before any subsequent surface treatment or mix is laid. Any unabsorbed primer shall first be blotted with an application of sand, using the minimum quantity possible. The work shall be done as per BOQ provisions.

5.10 Tack Coat

Over the primed surface, a tack coat should be applied in accordance with Clause 503 of MORTH Specifications.

The binder used for tack coat shall be bitumen emulsion complying with IS 8887 of a type and grade as specified in the Contract or as directed by the Engineer.

The tack coat distributor shall be a self-propelled or towed bitumen pressure sprayer, equipped for spraying the material uniformly at a specified rate. Hand spraying of small areas, inaccessible to the distributor, or in narrow strips, shall be performed using a pressure hand sprayer or as directed by the Engineer.

The surface on which the tack coat is to be applied shall be clean and free from dust, dirt, and any extraneous material, and be otherwise prepared in accordance with the requirements of Clauses 501.8 and 902 as appropriate. Immediately before the application of the tack coat, the surface shall be swept clean with a mechanical broom, and high-pressure air jet, or by other means as directed by the Engineer.

The application of tack coat shall be at the rate specified in the Contract, and shall be applied uniformly. If rate of application of Tack Coat is not specified in the contract then it shall be at the rate specified in Table-5.9: Requirement of Viscosity and quantity of Liquid bituminous Tack Coat (As per Table 500-5 of MORTH Specifications).

Table-5.9: Requirement of Viscosity and quantity of Liquid bituminous Tack Coat (As per Table 500-5 of MORTH Specifications).

Sl No	Type of Surface	Quantity of Liquid bituminous material in Kg per sq.m.area
i)	Normal bituminous surfaces	0.20 to 0.30
iii)	Granular surfaces treated with primer	0.25 to 0.30
iv)	Non bituminous surfaces Cement concrete pavement	0.30 to 0.35

The normal range of spraying temperature for a bituminous emulsion shall be 20°C to 70°C and for a cutback, 50°C to 80°C. The work shall be done as per Clause 503 MORTH V revision and as per BOQ provisions.

5.11 Bituminous Macadam

The bitumen shall be paving bitumen of Penetration Grade complying with Indian Standard Specifications for "Paving Bitumen" IS:73.
Aggregate grading and binder content: When tested in accordance with IS: 2386 Part 1 (wet sieving method), the combined aggregate grading for the particular mixture shall fall within the limits shown in Table-5.10: Composition of Bituminous macadam (BM) (As per Table 500-7 of MORTH Specification) for the grading specified in the Contract. The type and quantity of bitumen, and appropriate thickness, are also indicated for each mixture type.

The aggregates shall be proportioned and blended to produce a uniform mixture complying with the requirements of Table 500-7.

Table-5.10: Composition of Bituminous macadam (BM)
(As per Table 500-7 of MORTH Specification)

Mix designation Nominal aggregate size Layer thickness	Grading 1 40mm 80 -100mm	Grading 2 19 mm 50 - 75 mm
IS Sieve (mm)	Cumulative % by weight of total aggregate passing	
45	100	
37.5	90-100	
26.5	75-100	100
19	-	90-100
13.2	35-61	56-88
4.75	13-22	16-36
2.36	4-19	4-19
0.3	2-10	2-10
0.075	0-8	0-8
Bitumen content, % by weight of total mixture[1]	3.1 - 3.4	3.3 - 3.5
Bitumen grade	35 to 90	35 to 90

5.11.1 Preparation of the Base

The base on which bituminous macadam is to be laid shall be prepared, shaped and compacted to the required profile in accordance with Clause 501.8 and 902.3 as appropriate, or as directed by the Engineer.

5.11.2 Preparation and transportation of the Mixture

The provisions of Clauses 501.3 and 501.4 shall apply.

5.11.3 Spreading

The provisions of Clauses 501.5.3 shall apply.

5.11.4 Compaction

Compaction shall be carried out in accordance with the provisions of Clause 501.6 and 501.7. The details of mixing, laying and rolling temperature of BM mix is as indicated in **Table-5.11:** Mixing, Laying and Rolling Temperatures for Bituminous Mixes (Degree celcius) (As per Table 500-2 of MORTH Specifications)
Rolling shall be continued until the specified density is achieved, or where no density is specified, until there is no further movement under the roller. The required frequency of testing is defined in Clause 903.

Table-5.11: Mixing, Laying and Rolling Temperatures for Bituminous Mixes (Degree Celsius) (As per Table 500-2 of MORTH Specifications)

Bitumen Viscosity grade	Bitumen Temperature (°C)	Aggregate Temperature (°C)	Mixed Material Temperature(°C)	Rolling Temperature (°C)	Laying Temperature (°C)
VG-40	160-170	160-170	160-170	100 Min	150 Min
VG-30	150-165	150-170	150-165	90 Min	140 Min
VG-20	145-165	145-170	145-165	85 Min	135 Min
VG-10	140-160	140-165	140-160	80 Min	130 Min

The bituminous macadam shall be covered with either the next pavement course or wearing course, as the case may be, within a maximum of forty-eight hours. If there is to be any delay, the course shall be covered by a seal coat to the requirement of Clause 513 before opening to any traffic. The seal coat in such cases shall be considered incidental to the work and shall not be paid for separately. The work shall be done as per Clause 504 MORTH V revision and as per BOQ provisions.

5.12 Bituminous Concrete

This work shall consist of construction in a single layer of bituminous concrete on a previously prepared Bituminous Macadam (BM) surface. The work shall be done as per Clause 507 MORTH V revision and as per BOQ provisions.

Bitumen: The bitumen shall be paving bitumen of Penetration grade complying with Indian Standard Specification for Paving Bitumen, IS: 73 and of the penetration indicated in Table 500-17, for bituminous concrete. The coarse aggregates shall be generally as specified in Clause 507.2.2, except that the aggregates shall satisfy the physical requirements of Table 500-17.

Requirements for the mixture: Apart from conformity with the grading and quality requirements for individual ingredients, the mixture shall meet the requirements set out in Table-5.12: Composition of Bituminous Concrete (As per Table 500-17 of MORTH Specifications) and Table-5.13: Requirement of Bituminous Concrete (As per Table 500-11: of MORTH Specifications).

Table-5.12: Composition of Bituminous Concrete (As per Table 500-17 of MORTH Specifications)

Grading	**1**	**2**
Nominal aggregate size	19 mm	13.2 mm
Layer Thickness	50 mm	30-40 mm
IS Sieve[1] (mm)	**Cumulative % by weight of total aggregate passing**	
45		
37.5		
26.5	100	
19	90-100	100
13.2	59-79	90-100
9.5	52-72	70-88
4.75	35-55	53-71
2.36	28-44	42-58
1.18	20-34	34-48
0.6	15-27	26-38
0.3	10-20	18-28
0.15	5-13	12-20
0.075	2-8	4-10
Bitumen content % by mass of total mix[2]	Min 5.2	Min 5.4

Notes: 1. The combined aggregate grading shall not vary from the low limit on one sieve to the high limit on the adjacent sieve.
2. Determined by the Marshall method.
3. Job mix formula shall be generally as specified in Clause 507.3.3 and the results of tests enumerated in Table 500-19.

Table-5.13: Requirement of Bituminous Concrete
(As per Table 500-11: of MORTH Specifications)

Properties	**Viscosity Grade Paving Bitumen**	**Modified Bitumen**		**Test Method**
		Hot climate	**Cold climate**	
Compaction level	75 blows on each face of specimen			
Minimum stability (kN at 60 °C)	9.0	12.0	10.0	AASHTO T245
Marshall flow (mm)	2-4	2.5-4	3.5-5	AASHTO T245
Marshall Quotient (Stability/Flow)	2-5	2.5-5		MS-2 and ASTM D2041

% Air voids	3-5	
% Voids Filled with Bitumen (VFB)	65-75	
Coating of aggregate particle	95% minimum	IS: 6241
Tensile strength ratio	80% minimum	AASHTO T283
% Voids in Mineral Aggregate (VMA)	Minimum percent voids in mineral aggregate (VMA) are set out in Table 500-12 of MORTH	

5.12.1 Rolling

Immediately after the spreading of mix it shall be thoroughly compacted by rolling with vibratory rollers moving at a speed not more than 5 km per hour. Rolling shall be continued till the mix is thoroughly compacted to meet the general provisions of clauses 501.6 and 501.7.

5.12.2 Opening to Traffic

Traffic shall be allowed on the road after a lapse of minimum 24 hours, preferably 48 hours after laying as approved by the Employer's Representative.

5.13 Quality Control of Road restoration works

5.13.1 General

To ensure the requisite quality of construction, the materials and works shall be subjected to quality control tests, as described below. The testing frequencies set forth are the desirable minimum. The Engineer shall have the full authority to increase the frequencies of tests as he may deem necessary to ensure that the materials and works comply with the appropriate Specifications.

Test procedures for the various quality control tests are indicated in the respective Sections of these Specifications or for certain tests within this Section. Where no specific testing procedure is specified, the tests shall be carried out in accordance with the prevailing accepted engineering practice, subject to the approval of the Engineer.

5.13.2 Tests on Earthwork for Embankment and Subgrade Construction

(i) Sand content [IS:2720 (Part IV)]
1-2 tests per 8000 cu. metres of soil or as per MORTH.

(ii) Plasticity Test [IS:2720 (Part V)]
Each type to be tested, 1-2 tests per 8000 cu. metres of soil or as per MORTH.

(iii) Density Test [[IS:2720 (Part VII)].

Each soil type to be tested, 1-2 tests per 8000 cubic metres of soil or as per MORTH.

(iv) Deleterious Content Test [IS:2720 (PartXXVII)]
As and when required by the Engineer.

(v) Moisture Content Test [IS:2720(Part II)]
One test for every 250 cubic metres of soil or as per MORTH.

(vi) CBR Test on materials to be incorporated in the subgrade on soaked/unsoaked samples [IS:2720 (part XVI)]
One test for every 3000 m^3 at least or closer as and when required by the Engineer or as per MORTH.

5.13.3 Compaction control:

Control shall be exercised by taking at least one measurement of density for each 500 square metres of compacted area, or closer as required to yield the minimum number of test results for evaluation a day's work on statistical basis. The determination of density shall be in accordance with IS:2720 (part XXVIII). Test's locations shall be chosen only through random sampling techniques. Control shall not be based on the result of any one test but on the mean value of a set of 5-10 density determinations. The number of tests in one set of measurements shall be 5 as long as it is felt that sufficient control over borrow material and the method of compaction is being exercised. If considerable variations are observed between individual density results, the minimum number of tests in one set of measurement shall be increased to 10. The acceptance of work shall be subject to the condition that the mean dry density equals or exceeds the specified density and the standard deviation for any set of results is below 0.08 gm/cc.

However, for earthwork in subgrade and in top 500 mm portion of the embankment below the subgrade, at least one density measurement shall be taken for every 100 square metres of the compacted area provided further `that the number of tests in each set of measurements shall be at least 10. In other respects, the control shall be similar to that described earlier.

5.13.4 Tests on Granular Subbase (GSB) and Wet mix macadam (WMM) layers

The tests and their frequencies for the different types of bases and sub-base shall be as given in **Table 5.14**.

Table –5.14: Control Tests and their frequencies for Granular Sub base (GSB) and Wet mix macadam (WMM) layers

Sl.No.	Types of Construction	Test	Frequency***
1.	Granular sub-base	i) Gradation	One test per 200 m^3
		ii) Atterbergs limit	One test per 200 m^3
		iii) Moisture content prior to compaction	One test per 250 m^2
			One test per 500 m^2
		iv) Density of compacted layer	As required
		v) Deleterious constituents	As required
		vi) C.B.R	

Sl.No.	Types of Construction	Test	Frequency***
2.	Lime/Cement Stabilised	i) Purity of lime (for lime-soil stabilization	One test for each consignment, subject to a minimum of one test per 5 tonnes of lime.
		ii) Lime/Cement content	Regularly, through procedural checks.
		iii) Degree of pulverisation	Periodically as considered necessary.
		iv) CBR test on a set of 3 specimens	As required
		v) Moisture content prior to compaction	One test per 250 m^3.
		vi) Density of compacted layer	One test per 500 m^2
		vii) Deleterious constituents	As required
3	Wet mix Macadam	i) Aggregate Impact Value	One test per 200m^3 of aggregate
		ii) Grading	One test per 100 m^3 of aggregate
		iii) Flakiness Index	One test per 200 m^3 of aggregate
		iv) Atterberg limits of portion of aggregate passing 425 micron sieve	One test per 100 m^3

***** Or as per MORTH**

5.13.5 Tests on Bituminous Constructions

The tests and their frequencies for the different types of bituminous works shall be as given in **Table - 5.15** hereunder.

Table – 5.15: Control Tests and their Frequency for Bituminous Works

Sl. No.	Types of Construction	Test	Frequency
1.	Prime Coat/Tack Coat	i) Quality of binder	As Required
		ii) Binder temperature for an application	At regular close intervals
		iii) Rate of spread of binder	Two tests per day

Sl. No.	Types of Construction	Test	Frequency
2	Bituminous macadam (BM) / Bituminous Concrete (BC)	i) Quality of binder	As required
		ii) Aggregate impact value, flakiness index, and stripping value of aggregates	One test per 50-100m^3 of aggregate
		iii) Mix-grading	One set of test on individual constituents and mixed aggregates from the dryer for each 100 tonnes of mix subject to a maximum of two sets per plant per day.
		iv) Control of temperature of binder in boiler, aggregate in the dryer and mix at the time of laying and rolling	At regular close interval.
		v) Stability of mix (vide ASTM:D-1559)	For each 100 tonnes of mix produced, a set of three Marshall specimens to be prepared and tested for stability, flow value density, and void content, subject to a minimum of two sets being tested per plant per day.
		vi) Binder content and gradation in the mix (Binder content test vide ASTM:D-2172)	One test for each 100 tonnes of mix subject to a minimum of two tests per day per plant.
		vii) Rate of spread of mixed material	Regular control through checks on the weight of mixed material and layer thickness.
		viii) Density of compacted layer	One test per 250 m^2 area

5.14 Slab Culvert

Slab culverts shall be constructed at the specified locations of the existing cross-drainage works, as per the drawings or as directed by the Engineer. The Concrete works specifications for the construction of RC slab and the rubble masonry specifications for the supporting rubble walls are given in chapter 4 and chapter 8, respectively, and they shall be followed.

5.14.1 Bitumen at Location of Contact

The Bitumen to be used on the top of the bed concrete at the location of contact of RCC slab above in two coats, shall be straight run bitumen of specified grade.

5.14.2 Graded Gravel Free Draining Backfill

On each side of the uncoursed rubble walls supporting the slab culvert, a free-draining backfill of thickness 200 mm shall be provided. The material for this backfill shall be granular consisting of sound, tough, durable particles of crushed or uncrushed gravel, crushed stone or brickbats which will not become powdery under loads and in contact with water. The material shall be free from soft, thin, elongated or laminated pieces and vegetable or other deleterious substances. It shall be graded and meet the grading requirements specified in Table 5.10 below.

Table 5.10

Sieve Designation	Percent Passing by Weight
10 mm	100
4.75 mm	30-65
425 microns	5-30
150 microns	0-10

5.14.3 Weep Holes

Weep holes as shown on the drawings or as directed by the Engineer shall be provided in the masonry to drain water from the backfilling. Weep holes shall be of asbestos-cement pipes conforming to IS 6908 in rubble walls, with a necessary M10 concrete cushioning, 75 mm thick. They shall extend through the full width of the masonry at a spacing of 1.5 m c/c and with slope of about 1 vertical to 20 horizontals (or as shown on the drawings) towards the draining face.

5.15 Pipe Drains

Wherever required, pipe drains shall be provided for cross drainage purposes. The sequence of construction shall be as follows:

(a) laying of sand/shingle bedding on the original ground,
(b) laying of PCC of M10 grade,
(c) laying of concrete pipes of NP3 class as per IS 458,
(d) Constructing embankment above in compacted murum, laying of the sub-base and Wet mix Macadam as specified herein above.

The details of above works as directed by Engineer shall be followed.

5.15.1 Materials for Pipe Drains

All materials used in the construction of pipe drains shall conform to the requirements of the Specifications. RCC pipes of NP3 class shall conform to IS 458.

Each consignment of cement concrete pipes shall be inspected, tested if necessary, and approved by Engineer at the place of manufacture or at site before their incorporation in the Works.

5.15.2 Excavation for pipes

The foundation bed for pipe drain shall be executed true to the lines and grades shown on the drawings or as directed by the Engineer. The pipes shall be placed in a shallow excavation of the natural ground in open trenches cut into the existing embankment, lowered to the levels as shown in the drawings. Where trenching is involved, its width on either side of the pipe shall not be less than 200 mm nor more than one-third the diameter of the pipe. The sides of the trench shall be as nearly vertical as possible.

When during excavation, the material encountered is soft, spongy or other unstable soil, unless other special construction methods are called for as indicated on drawings, such unsuitable material shall be removed upto a depth of 600 mm or as directed by the Engineer. Before placing any backfill material, the exposed surface of the soft soil shall be lightly compacted with one pass of a 0.5 T roller. On the lightly compacted surface, coarse sand and shingle shall be spread in two successive layers of 300 mm and each layer shall be compacted by rolling with a min.0.5 T roller and with a minimum of 10 passes each, both in longitudinal and transverse directions.

When bedrock or boulder strata are encountered, excavation shall be taken down at least 300 mm below the bottom level of the pipe as directed by the Engineer and space filled with approved sand and shingle and thoroughly compacted to provide adequate support for the pipes.

Trenches shall be kept free from water until the pipes are installed and the joints have been hardened. For this purpose, Contractor shall suggest necessary method for diverting the water.

5.15.3 Bedding for pipe

The bedding surface shall provide a firm foundation of uniform density throughout the length of the pipe drain and shall conform to the specified level and grade.

The pipe shall be bedded in a cradle of concrete having a mix not leaner than M-10. The pipes shall be laid on the concrete bedding before the concrete has set.

5.15.4 Laying of pipes

No pipe shall be placed in position until the foundations have been approved by the Engineer. When pipes are to be laid adjacent to each other, they shall be separated by a distance at least equal to or greater than half the diameter of the pipe, subject to a minimum of 450 mm.

The laying of pipes on the prepared concrete foundation shall commence at the outlet and proceed towards the inlet, being completed to the specified lines and grades. The pipes shall be fitted and matched so that when laid they form a drain with a smooth uniform invert.

Any pipe found to be defective or damaged during laying shall be removed at the Contractor's expense.

5.15.5 Jointing

All the joints shall be made with care so that their interior face is smooth and consistent with the interior surface of the pipes. The ends of the pipes should be so shaped as to form a self-centering joint with a jointing space 13 mm wide. The jointing space shall be filled with cement mortar (1 cement to 2 sand) mixed sufficiently dry to remain in position when forced with a trowel or rammer. Care shall be taken to fill all voids and excess mortar shall be removed. After finishing, the joints shall be kept covered and damp for at least four days.

5.15.6 Backfilling

Trenches shall be backfilled with selected murum as per the specifications given in this part. Backfilling up to 0.3 metres above the top of the pipe shall be carefully done, and the murum shall be thoroughly consolidated under the haunches of the pipe.

5.16 Measurement

5.16.1 Slab Culvert

(a) Measurement of in-situ concrete work shall be as specified in chapter 4 of this specification.

(b) Measurement of masonry shall be as specified in chapter 8 of this specification.

(c) Bitumen at locations of contact with concrete surface shall be measured in square metres over area covered in plan and the rates shall include cleaning the surfaces, applying in two coats, etc., as specified.

(d) Graded gravel free draining backfill shall be measured in cubic metres and the rate shall include supplying, backfilling, etc., as specified.

(e) Measurement for weep holes shall be running metres and the rates shall include providing and fixing in rubble masonry walls with necessary concrete cushioning to lines and levels as specified.

5.16.2 Pipe Drains

Ancillary works such as excavation, backfilling, laying P.C.C below pipe, etc., shall be paid for separately, as provided under respective clauses.

End of Chapter-5

CHAPTER 6

STRUCTURAL STEEL WORK

CHAPTER 6

STRUCTURAL STEEL WORK

6.1 Applicable Codes and Specifications

The supply, fabrication, erection and painting of structural steel works shall comply with the following specifications, standards and codes unless otherwise specified herein. All standards, specifications and codes of practices referred to herein shall be the latest editions including all applicable official amendments and revisions.

1.	IS: 808	Dimensions for Hot Rolled Steel sections
2.	IS: 814	Covered Electrodes for Manual Metal Arc Welding of Carbon and Carbon Maganese Steel
3.	IS: 800	Code of Practice for General Construction in Steel
4.	IS: 801	Code of Practice for Use of Cold Formed Light Gauge Steel Structural Members in General Building Construction
5.	IS: 806	Code of Practice for Use of Steel Tubes in General Building Construction
6.	IS: 7205	Safety Code for Erection of Structural Steel Work
7.	IS: 7215	Tolerances for Fabrication of Steel Structures
8.	IS: 4000	High Strength Bolts in Steel Structure – Code of Practice
9.	AISC	Specifications for Design, Fabrication and Erection of Buildings
10.	IS: 1161	Steel Tubes for structural purposes
11.	IS:102	Ready Mixed paint, Brushing, Red Lead, Non-setting, Priming.
12.	IS:110	Ready Mixed paint, brushing, grey filler for enamels for use over primers.
13.	IS:117	Ready Mixed paint, Brushing, Finishing, Exterior Semigloss for general purposes, to Indian Standard colours.
14.	IS:158	Ready Mixed paint, Brushing, Bituminous, Black, Lead free, Acid, Alkali and heat resisting.
15.	IS:159	Ready Mixed paint, Brushing, Acid resisting for protection against acid fumes, colour as required.
16.	IS:341	Black Japan, Types A, B and C
17.	IS:2339	Aluminium paint for general purposes, in Dual container
18.	IS:2932	Specification for enamel, synthetic, exterior, type 1, (a) undercoating, (b) finishing
19.	IS:2933	Specification for enamel, exterior, type 2, (a) undercoating, (b) finishing
20.	IS:5905	Sprayed aluminium and zinc coatings on Iron and Steel.
21.	IS:6005	Code of practice for phosphating of Iron and Steel.
22.	IS:9862	Specification for ready mixed paint, brushing, bituminous, black, lead free, acid, alkali, water & chlorine resisting.
23.	IS:13183	Aluminium paint, Heat resistant.
24.	SIS-05-5900	(Swedish Standard)
25.	IS: 1239	Mild steel tubes, tubulars and other Wrought steel fittings Part 1 – Mild steel tubes Part 2 – Mild steel tubulars and other wrought steel pipe fittings

26.	IS : 1363 (Parts 1 to 3)	Hexagon Head Bolts, Screws and Nuts of product Grade C (Size range M5 to M64)
27.	IS : 1367 (All parts)	Technical Supply Conditions for Threaded Fasteners
28.	IS : 1852	Rolling and Cutting Tolerances for Hot Rolled Steel Products
29.	IS : 1977	Structural Steel (Ordinary Quality)
30.	IS : 2062	Steel for General Structural Purposes
31.	IS : 2074	Ready Mixed Paint, Air drying, Red Oxide Zinc Chrome and Priming
32.	IS : 3502	Steel Chequered Plate
33.	IS : 3757	High Strength Structural Bolts
34.	IS : 5369	General Requirements for Plain Washers and Lock Washers
35.	IS : 5372	Taper Washers for Channels
36.	IS : 5374	Taper Washer for 1 Beams
37.	IS : 6610	Heavy Washers for Steel Structures
38.	IS : 8500	Structural Steel-microalloyed (medium and high strength qualities)
39.	IS : 803	Code of practice for design, fabrication and erection of vertical mild steel cylindrical welded storage tanks
40.	IS : 816	Code of Practice for use of Metal Arc Welding for General construction in Mild Steel
41.	IS : 822	Code of Procedure for Inspection of Welds
42.	IS : 1182	Recommended Practice for Radiographic examination of Fusion – Welded Butt Joints in Steel Plates
43.	IS : 1200	Method of Measurement in Building Civil Works
44.	IS : 1477	Code of Practice for Painting of (Parts 1&2) Ferrous Metals in Buildings
45.	IS : 2595	Code of Practice for Radiographic Testing
46.	IS : 3658	Code of Practice for Liquid Penetrant Flaw Detection
47.	IS : 5334	Code of Practice for Magnetic Particle Flaw Detection of Welds
48.	IS : 9595	Recommendations for Metal Arc Welding of Carbon and Carbon Manganese Steel
49.	IS : 1367	Technical, Supply, Conditions for steel (Part 13) threaded fasteners
50.	IS : 1573	Electroplated Coating of Zinc on Iron and Steel
51.	IS : 2629	Recommended Practice for Hot Dip Galvanising of Iron and Steel
52.	IS : 2633	Method of Testing Uniformity of Coating on Zinc Coated Articles
53.	IS : 4736	Hot Dip Zinc coating on Mild steel tubes
54.	IS : 4759	Hot Dip Zinc coating on Structural Steel and other Allied products
55.	IS : 5905	Sprayed Aluminium and Zinc Coatings on Iron and Steel
56.	IS : 6158	Recommended Practice for Safeguarding against Embrittlement of Hot Dip Galvanised Iron and Steel
57.	IS : 6159	Recommended Practice for Design and preparation of Material Prior to Galvanising
58.	IS : 6745	Methods for Determination of Weight of Zinc Coating on Zinc coated Iron and Steel Articles

6.2 Steel Materials

Steel materials shall comply with the codes referred to in Sub-Clause 6.1.
All materials used shall be new, unused and free from defects.

Steel conforming to IS:1977 shall be used only for the following:

Fe310-0(St 32-0)	For general purposes such as door/window frames, grills, steel gates, handrails, fence posts, tee bars and other non-structural use.
Fe410-0(St 42-0)	For structures not subjected to dynamic loading other than wind loads such as: Platform roofs, foot over bridges, building, factory sheds etc.
Fe10-0(St 42-0)	Grade steel shall not be used a) If welding is to be employed for fabrication b) If site is in severe earthquake zone c) If plastic theory of design is used

6.3 Drawings prepared by the Employer

Design drawings will be furnished to the Contractor and all drawings so furnished shall form a part of this specification in case of Item Rate Contracts. These design drawings prepared by the Engineer will show all the levels, forces on members, size and orientation of each member, location/size of openings to enable the Contractor to prepare drawings for fabrication and erection. It shall be clearly understood that these drawings are not intended to show connection details, thickness of members, cuts, notches, bends and such other details.

The Engineer reserves the right to make changes. Revisions to drawings, even after release for preparation of shop drawings, are very likely to be made to reflect additional data/details received and updated requirements. Revisions to drawings and any new drawings made to include additional work by the Contractor shall be considered a part of this specification and contract. The Employer shall not entertain any extra claims on this account.

Where the fabrication drawings are to be furnished by the Engineer, he will issue to the Contractor the required copies of such drawings in the sequence required for the fabrication of the components in the order they will be required to be erected at site. Such drawings will be issued in the required numbers for the Contractor to adhere to the project schedule.

Should the Contractor during the execution of his work, find discrepancies in the information furnished by the Engineer, he shall refer such discrepancies to the Engineer before proceeding with the work.

6.4 Drawings prepared by the Contractor

The Contractor shall prepare all fabrication and erection drawings for the entire work. All the drawings for the entire work shall be prepared in metric units. The drawings shall preferably be of one standard size and the details shown there in shall be clear and legible.

The Contractor shall not commence detailing unless Engineer's design drawings are officially released for preparation of shop drawings. The Contractor shall be responsible for the correctness of all fabrication drawings. The Contractor shall revise fabrication drawings to reflect all revisions in design drawings as and when the Engineer makes such revisions.

All fabrication drawings shall be submitted to the Engineer for approval.

No fabrication drawings will be accepted for the Engineer's approval unless they have been checked and approved by the Contractor's qualified structural engineer and accompanied by an erection plan showing the location of all detailed pieces. The Contractor shall ensure that connections are detailed to facilitate the ease of erection of structures and the making of field connections.

Fabrication shall commence only after the Engineer has approved the fabrication drawings. Approval by the Engineer of any of the drawings shall not relieve the Contractor from the responsibility for correctness of engineering and design of connections, workmanship, fit of parts, details, material, errors or omissions of any and all work shown thereon. The Engineer's approval shall constitute approval of the size of members, dimensions and general arrangement but shall not constitute approval of the connections between members and other details.

The drawings prepared by the Contractor and all subsequent revisions etc. shall be at the cost of the Contractor for which no separate payment will be made.

6.5 Fabrication

6.5.1 General

All workmanship and finish shall be of the best quality and shall conform to the best approved method of fabrication. All materials shall be finished straight and shall be machined/ground smooth true and square where so specified. All holes and edges shall be free of burrs. Shearing and chipping shall be neatly and accurately done and all portions of work exposed to view shall be neatly finished. Unless otherwise approved by the Employer's Representative, reference may be made to relevant IS codes for providing standard fabrication tolerance. Material at the shops shall be kept clean and protected from weather.

6.5.2 Connections

Shop/field connections shall be as per approved fabrication drawings.

In case of bolted connections, taper washers or flat washers or spring washers shall be used with bolts as necessary. In case of high strength friction grip bolts, hardened washers are used under the nuts or the bolt heads whichever are turned to tighten the bolts. The length of the bolt shall be such that at least one thread of the bolt projects beyond the nut, except in the case of high-strength friction-grip bolts, where this projection shall be at least three times the pitch of the thread.

In all cases where bearing is critical, the unthreaded portion of bolt shall bear on the members assembled. A washer of adequate thickness may be provided to exclude the threads from the bearing thickness, if a longer grip bolt is required for this purpose.

All connections and splices shall be designed for full strength of members or loads. Column splices shall be designed for the full tensile strength of the minimum cross section at the splice.

All bolts, nuts, washers, electrodes, screws etc., shall be supplied/brought to site 10% above the requirement in each category and size. Rates shall cover the cost of this extra quantity.
All members likely to collect rain water shall have drain holes provided.

6.5.3 Straightening

All materials shall be straight and, if necessary, before being worked shall be straightened and/or flattened by pressure and shall be free from twists. Heating or forging shall not be resorted to without the prior approval of the Employer's Representative in writing.

6.5.4 Rolling and Forming

Plates, channels, R.S.J. etc., for circular bins, bunkers, hoppers, gantry girders, etc., shall be accurately laid off and rolled or formed to required profile/shape as called for on the drawings. Adjacent sections shall be match-marked to facilitate accurate assembly, welding and erection in the field.

6.5.5 High Strength Friction Grip Bolting

Inspection after tightening of bolts shall be carried out as stipulated in the appropriate standards depending upon the method of tightening and the type of bolt used.

6.5.6 Welding

Welding procedure shall be submitted to the Employer's Representative for approval. Welding shall be entrusted to qualified and experienced welders who shall be tested periodically and graded as per IS 817, IS : 7310 (Part 1) and IS : 7318 (Part 1).

While fabricating plated beams and built-up members, all shop splices in each component part shall be made before such component part is welded to other parts of the members. Wherever weld reinforcement interferes with proper fit-up between components to be assembled off welding, these welds shall be ground flush before assembly.

Approval of the welding procedure by the Employer's Representative shall not relieve the Contractor of his responsibility for correct and sound welding without undue distortion in the finished structure.

No welding shall be done when the surface of the members is wet nor during periods of high wind.

Each layer of a multiple-layer weld, except the root and surface runs, may be moderately peened with light blows from a blunt tool. Care shall be exercised to prevent scaling or flaking of weld and base metal from overpeening.

No welding shall be done on base metal at a temperature below -5 °C. Base metal shall be preheated to the temperature as per relevant IS codes.

Electrodes other than low-hydrogen electrodes shall not be permitted for thicknesses of 32 mm and above.

All welds shall be inspected for flaws by any of the methods described under Sub-clause 6.8.3. The method to be adopted shall be agreed upon with the Employer's Representative.

The correction of defective welds shall be carried out in a manner approved by the Employer's Representative without damaging the parent metal. When a crack in the weld is removed, magnetic particle inspection or any other equally positive means approved by the Employer's Representative shall be used to ensure that the whole of the crack and material upto 25 mm beyond each end of the crack has been removed. The Contractor shall bear the cost of all such tests and operations incidental to correction.

6.6 Tolerances

The dimensional and weight tolerances for rolled shapes shall be in accordance with IS : 1852 for indigenous steel and equivalent applicable codes for imported steel. The tolerances for fabrication of structural steel shall be as per IS : 7215.

Cutting, punching, drilling, welding, and fabrication tolerances shall be generally as per the relevant IS codes.

6.7 End Milling

Where compression joints are specified to be designed for bearing, the bearing surfaces shall be milled to ensure they are true and square, thereby ensuring proper bearing and alignment.

6.8 Inspection

6.8.1 General

The Contractor shall provide the Employer's Representative with due notice in advance of the works being made ready for inspection. All rejected material shall be promptly removed from the shop and replaced with new material for the Employer's Representative's inspection. The

fact that certain material has been accepted at the Contractor's shop shall not invalidate final rejection at site by the Employer's Representative if it fails to conform to the requirements of these specifications, to be in proper condition or has fabrication inaccuracies which prevent proper assembly nor shall it invalidate any claim which the Employer may make because of defective or unsatisfactory materials and/or workmanship.

No materials shall be painted or despatched to site without inspection and approval by the Employer's Representative unless such inspection is waived in writing by the Employer's Representative.

The Contractor shall provide all the testing and inspection services and facilities for shop work except where otherwise specified.

For fabrication work carried out in the field, the same standard of supervision and quality control shall be maintained as in shop-fabricated work. Inspection and testing shall be conducted in a manner satisfactory to the Employer's Representative.

Inspection and tests on structural steel members shall be as set forth below.

6.8.2 Material Testing

If mill test reports are not available for any steel materials, the Contractor shall test the same to the Employer's Representative's satisfaction to demonstrate conformity with the relevant specification.

6.8.3 Tests on Welds

6.8.3.1 Magnetic Particle Test

Where welds are examined by magnetic particle testing, such testing shall be carried out in accordance with relevant IS codes. If heat treatment is performed, the completed weld shall be examined after the heat treatment. All defects shall be repaired and retested. Magnetic particle tests shall be conducted using an alternating current. Direct current may be used with the permission of the Employer's Representative.

6.8.3.2 Liquid Penetrant Inspection

In the case of welds examined by Liquid Penetrant Inspection, such tests shall be carried out in accordance with relevant IS Code. All defects shown shall be repaired and rechecked.

6.8.3.3 Radiographic Inspection

All full strength butt welds shall be radiographed in accordance with the recommended practice for radiographic testing as per relevant IS code.

6.8.4 Dimensions, Workmanship & Cleanliness

Members shall be inspected at all stages of fabrication and assembly to verify that dimensions, tolerances, alignment, surface finish and painting are in accordance with the requirements shown in the Contractor's approved fabrication drawings.

6.8.5 Test Failure

In the event that any member fails to satisfy inspection or test requirements, the Contractor shall notify the Employer's Representative. The Contractor must obtain permission from the Employer's Representative before any repair is undertaken. The quality control procedures to be followed to ensure satisfactory repair shall be subject to approval by the Employer's Representative.

The Employer's Representative has the right to specify additional testing as he deems necessary, and the additional cost of such testing shall be borne by the Employer, only in case of successful testing.

The Contractor shall maintain records of all inspection and testing which shall be made available to the Employer's Representative.

6.9 Shop Matching

For structures like bunkers, tanks, etc. shop assembly is essential. For other steel work, such as columns and tie beams/bracings, may need to be shop assembled to ensure satisfactory fabrication, obtain adequate bearing areas, etc., if so desired by the Employer's Representative. The Contractor shall carry out all these shop assemblies.

6.10 Marking of Members

After checking and inspection, all members shall be marked for identification during erection. This mark shall correspond to distinguishing marks on approved erection drawings and shall be legibly painted and stamped on it. The erection mark shall be stamped with a metal dye with figures at least 20 mm high and to such optimum depth as to be visible.

All erection marks shall be on the outer surface of all sections and near one end, but clear of bolt holes. The marking shall be so stamped that they are easily discernible when sorting out members. The stamped marking shall be clearly marked with a distinguishable paint to facilitate easy location.

Erection marks on like pieces shall be in identical locations. Members having lengths of 7.0 m or more shall have the erection mark at both ends.

6.11 Errors

Any error in shop fabrication which prevents proper assembling and fitting up of parts in the field by moderate use of drift pins or moderate amount of reaming will be classified by the

Employer's Representative as defective workmanship. Where the Employer's Representative rejects such material or defective workmanship, the same shall be replaced by materials and workmanship conforming to these Employer's Requirements by the Contractor, at no cost to the Employer.

6.12 Site Operations

The Contractor shall complete all preliminary works at site well before the arrival of structural steel, such as establishment of a well equipped and adequately staffed site office, stores, unloading gantry, unloading pre-assembly yard, labour quarters if any, electrical and water connections, electrical winches, derricks, cranes, compressors, all tools and tackles, rivet guns, welding sets, torque wrenches, spud wrenches, staging, etc., as well as experienced erection and supervisory personnel as part of this contract and any other work that may be necessary to start erection immediately after the arrival of the first batch of steel on site.

The Contractor shall furnish at his own expense, the necessary non-inflammable staging and hoisting materials or equipment required for the erection work and shall remove and take them away after completion of the job. The Contractor shall also provide necessary passageways, fences, safety belts, helmets, lights and other fittings to the satisfaction of the Employer's Representative and to meet the rules of local authorities and for protection to his men and materials. A licensed electrician shall be kept on the job for the entire duration of the work to maintain the Contractor's electrical equipment and connections.

The Contractor shall protect all existing plant, structures, piping, conduits, equipment and facilities against damage during erection. Any damage caused by Contractor shall be rectified entirely at his cost, to the satisfaction of the Employer's Representative. If work has to be carried out adjacent to existing switch yards or electrical installations which are live, the Contractor must ensure suitable safety precautions in consultation with Employer's Representative.

If a portion of the work of the project area cannot be made available to the Contractor for his activities due to operations being carried out by other agencies, he shall suitably modify his sequence of operations so as to continue work without interruption. The Contractor shall work in co-ordination with other agencies working on the project site and plan his work suitably so as not to hinder the progress of construction at site.

6.13 Acceptance of Steel, its Handling & Storage

The Contractor shall carefully check the steel to be erected at the time of acceptance. Any fabrication defects observed should be brought to the notice of the Employer's Representative.

No dragging of steel shall be permitted. All steel shall be stored 300mm above ground on suitable packing to avoid damage. It shall be stored in the order required for erection, with erection marks visible. All storage areas shall be prepared and maintained by the Contractor. Steel shall not be stored in the vicinity of areas where excavation or grading will be done and,

if so stored temporarily, this shall be removed by the Contractor well before such excavation and/or grading commences to a safe distance to avoid burial under debris.

Scratched or abraded steel shall be given a coat of primer in accordance with these Employer's Requirements for protection after unloading and handling prior to erection. All milled and machined surfaces shall be properly protected from rust/corrosion by suitable coating and also from damage.

6.14 Anchor Bolts & Foundations

The Contractor shall carefully check the location and layout of anchor bolts embedded in foundations constructed, to ensure that the structures can be properly erected as shown on the drawings. Any discrepancy in the anchor bolts/foundation shall be reported to the Employer's Representative.

Leveling of column bases to the required elevation may be done either by providing shims or three nuts on the upper threaded portion of the anchor bolt. All shim stock required for keeping the specified thickness of grout and in connection with the erection of structures on foundations, crane brackets, or at any other locations shall be of good M.S. plates and shall be supplied by the Contractor at his cost.

A certain amount of cleaning of the foundations and preparation of the area is considered normal and shall be carried out by the Contractor at no additional cost.

Where beams bear in pockets or on walls, bearing plates shall be set and levelled as part of the work. The Contractor will carry out all grouting under column base plates or beam bearing plates.

6.15 Assembly & Connections

Field connections may be affected by riveting, bolting, welding or by use of high strength friction grip bolts as shown on the design and erection drawings.

All field connection work shall be carried as per the drawings prepared by the Contractor. All bolts, nuts, washers, rivets, electrodes required for field connections shall be supplied by the Contractor.

All assembling shall be carried on a level platform.

Drifts shall be used only for drawing the work to proper position and must not be used to such an extent as to damage the holes. Size of drifts larger than the normal diameter of hole shall not be used. Any damaged holes or burrs must be rectified to the satisfaction of the Employer's Representative.

Corrections of minor misfits and a reasonable amount of reaming and cutting of excess stock from rivets shall be considered part of the erection process. Any error in the shop, which prevents proper fit on a moderate amount of reaming and slight chipping or cutting, shall be immediately reported to the Employer's Representative.

6.16 Erection

All structural steel shall be erected as shown on the drawings prepared by the Contractor. Proper size steel cable slings, etc., shall be used for hoisting. Guys shall not be anchored to existing structures, foundations, etc., unless so permitted by the Employer's Representative in writing. Care shall be taken to see that ropes in use are always in good condition.

Steel columns in the basement, if any, are to be lowered and erected carefully with the help of a crane and/or derrick without damaging the basement walls or floor.

Structural steel frames shall be erected plumb and true. Frames shall be lifted at points such that they are not liable to buckle and deform. Trusses shall be lifted only at node points. In the case of trusses, roof girders, all of the purlins and wind bracing shall be placed simultaneously and the columns shall be erected truly plumb on screed bars over the pedestals. All steel columns and beams shall be checked for plumb and level individually before and after connections are made. Temporary bracings shall be introduced wherever necessary to take care of all loads to which the structure may be subjected, including erection equipment and the operation thereof. Such bracings shall be left in place as long as may be required for safety and stability.

Chequered plates shall be fixed to supporting members by tack welding or by countersunk bolts as shown/specified in relevant drawings and/or as approved by the Employer's Representative. The edges shall be made smooth and no burrs or jagged ends shall be left. While splicing, care should be taken so that there is continuity in pattern between the two portions. Care should also be taken to avoid distortion of the plate while welding. The erection of chequered plates shall include:

(a) Welding of stiffening angles/vertical stiffening ribs
(b) Cutting to size and making holes to required shape wherever necessary to allow service piping and/or cables to pass through
(c) Splicing as shown in relevant drawings
(d) Smoothening of edges
(e) Fixing of chequered plates by tack welding or by countersunk bolts
(f) Providing lifting hooks for ease of lifting.

As erection progresses, the work shall be securely bolted to take care of all dead load, wind, seismic and erection stresses.

No riveting or welding or final bolting shall be done until the structure has been properly aligned and approved by the Employer's Representative. No cutting, heating or enlarging of the holes shall be carried out without the prior written approval of the Employer's Representative.

Test certificates shall be furnished by the Contractor.

6.17 Inspection

The Employer's Representative shall have free access to all parts of the job during erection and all erection shall be subjected to his approval. In case of faulty erection, all dismantling and re-erection required will be at the Contractor's cost. No paint shall be applied to rivet heads or field welds or bolts until these have been approved by the Employer's Representative.

6.18 Tolerances

6.18.1 General

Tolerances mentioned below shall be achieved after the entire structure or part thereof is in line, level and plumb.

6.18.2 Columns

Deviation of column axes at foundation top level with respect to true axes:

(a) In longitudinal direction	±5 mm
(b) In lateral direction	±5 mm

Deviation in the level of bearing surface of columns at foundation top with respect to true level	±5mm

Out of plumbness (verticality) of column axis from true vertical axis, as measured at column top:

(a)	For columns upto and including 15 metres in height	±1/1000 of column height in mm or ±15 mm whichever is less
(b)	For columns exceeding 15 metres in height	±1/1000 of column height in mm or ±20 mm whichever is less

Deviation in straightness in longitudinal and transverse planes of column at any point along the height	±1/1000 of column height in mm or ±10 mm whichever is less
Difference in erected position of adjacent pairs of columns along length or across width of building prior to connecting trusses/beams with respect to true distance	±10mm
Deviation in any bearing or seating level with respect to true level	±5 mm
Deviation in differences in bearing level of a member on adjacent pair of columns	±10 mm

both across and along the building

6.18.3 Trusses and Beams

Shift at the centre of span of top chord member with respect to the vertical plane passing through the centre of bottom chord	±1/250 of height of truss in mm or ±15 mm whichever is less
Lateral shift of top chord of truss at the centre of span from the vertical plane passing through the centre of supports of the truss	±1/1500 of span of truss in mm or ±15 mm whichever is less
Lateral shift in location of truss from its true vertical position	±10 mm
Lateral shift in location of purlin true position	±5 mm
Deviation in difference of bearing levels of trusses or beams from the true difference	i) ±20 mm for trusses ii) For beams: Depth < 1800mm: ±6mm Depth > 1800mm: ±10mm
Deviation in sag in chords and diagonals of truss between node points	1/1500 of length in mm or 10mm whichever is smaller
Deviation in sweep of trusses, beams etc. in the horizontal plane	1/1000 of span in mm subject to a maximum of 10 mm

6.18.4 Crane Girders & Rails

Shift in the centre line of crane rail with respect to centre line of web of crane girder	±5 mm
Shift in plan of alignment of crane rail with respect to true axis of crane rail at any point	±5 mm
Difference in alignment of crane rail in plan measured between any two points 2 metres apart along rail	±1 mm
Deviation in crane track with respect to Time gauge	
(a) For track gauges upto and Including 15 metres	±5 mm

(b)	For track gauges more than 15 metres	± [5 + 0.25 (S-15)] where S in metres is true gauge
Deviation in the crane rail level at any point from true level		±1/1200 of the gauge distance or ±10mm whichever is less
Difference in the crane rail actual levels between any two points 2 metres apart along the rail length		±2 mm
Difference in levels between crane track Rails at		
(a)	Supports of crane girders	±15 mm
(b)	Mid span of crane girders	± 20 mm
Relative shift of crane rail surfaces at a joint in plane and elevation		2 mm subject to grinding of surfaces for smooth transition
Relative shift in the location of crane stops (end buffers) along the crane tracks with track gauge S in mm		1/1000 of track gauge S in mm subject to maximum of 20 mm

6.19 Clean up of Work Site

During erection, the Contractor shall at all times keep the working and storage areas used by him free from accumulation of waste materials or rubbish. Before completion of erection, he shall remove or dispose in a satisfactory manner all temporary structures, waste and debris and leave the premises in a condition satisfactory to the Employer's Representative.

6.20 Painting

6.20.1 General

After steel has been erected, all bare and abraded spots, rivet heads, field welds, bolt heads and nuts shall be spot painted with primer. Before paint is applied, the surface shall be dry and free from dust, dirt, scale and grease. All surfaces inaccessible after erection shall receive two coats of the approved paint before erection.

6.20.2 Surface Treatment

All the surfaces of steel work to be painted shall be thoroughly cleaned of all loose mill scale, rust, grease, dirt and other foreign matter. The workmanship shall generally conform to the requirements of IS 1477- Part I.

Oil and grease removal shall be carried out either by solvent cleaning or by using alkali type degreasing agents. To remove grease material the surface shall be cleaned with solvents containing emulsifier. After cleaning, the surface shall be washed with water. When the

surface has cement pelter or salts, the cleaning shall be done with strong alkalies. After cleaning, water rinsing and subsequent passivation by dilute chromic acid rinsing shall be carried out to ensure that no traces of alkali is left on the surface. The procedure for cleaning by above mentioned methods shall be as per manufacturer's instructions.

Derusting and descaling of steel shall be carried out either manually, mechanically or chemically.

6.20.2.1 Manual or Hand Tool Cleaning

Loose mill scale, loose rust and loose paint shall be removed by wire brushing, scrapping, chipping, rubbing with abrasive paper or steel wool. This method shall not be employed when the surface has firmly adhering mill scale. After hand tool cleaning, the surface shall be rubbed with sand paper so as to ensure that no loose material exists and the surfaces shall be dusted off.

6.20.2.2 Mechanical Cleaning

Power Tool Cleaning:

This shall be carried out by employing power operated wire brushes. Power tool cleaning shall be resorted to only if sand/shot blasting is not possible/permissible and high quality of surface preparation is required.

The surface prior to treatment shall have been cleaned of dust and grease and heavier layers of rust removed by chipping.

The powertool cleaning shall remove loose mill scale and rust by adopting very thorough scrapping, grinding and machine brushing. After the surfaces are cleaned by compressed air, it shall have a pronounced metallic sheen.

Flame Cleaning:

Hard mill scale and rust shall be removed through Oxy-acetylene flame. Trained workmen shall carry out the work to ensure that only mill scale is removed without heating the parent steel. The work shall be carried out carefully on welded surfaces so that the strength of weld is not affected due to heating.

6.20.2.3 Sand Blasting and Shot Blasting

Sand/shot blasting shall only be carried out after removal of grease, oil and other contaminants. The work shall be carried out by impinging under pressure of air, a jet of sharp sand or granulated steel (steel grits) on to the metal surface. The process shall ensure complete removal of rust and firmly adhering mill scale. Special care shall be taken on weld areas to remove flux and spatter. Blasting shall ensure an even colour of the surface and the surface shall have silver grey colour. Precautions shall be taken when sand or shot blasting of light gauge steel surfaces to ensure that buckling does not occur due to continuous impingement of sand or steel shots under high velocity.

Sand/shot blasting shall be adopted for structures which are exposed to corrosive conditions for which superior paint protection is to be adopted. The finished surfaces shall conform to the requirements of Sa 2.5 or Sa 3 as per Swedish Standard SIS-05-5900 as required.

As sand blasting causes dust nuisance, necessary clearance shall be obtained by the Contractor from the Competent authorities prior to commencing sand blasting.

6.20.2.4 Chemical Cleaning (Pickling)

The cleaning shall be done by pickling in sulphuric, hydrochloric or phosphoric acids. Pickling shall be carried out in accordance with the detailed procedure as given in IS 6005. Washing after pickling shall remove all traces of the acids. All workpieces shall be thoroughly inspected, with particular attention to inaccessible corners.

All surfaces shall be cleaned thoroughly as per manufacturer's specification before application of primer.

6.20.3 Materials

6.20.3.1 Primer Paint

Anti-corrosive primers shall be either lead-based or lead-free types. Red lead primer shall conform to IS 102 and red oxide zinc chrome primer shall conform to IS 2074.

6.20.3.2 Finish Paint

Epoxy primer and epoxy paint shall be of the type as specified from an approved manufacturer.

Chlorinated rubber-based paint shall be of the manufacturer as specified or any equivalent approved manufacturer.

All the materials shall be of the best quality from an approved manufacturer. The Contractor shall obtain prior approval of the Employer's Representative for the brand of manufacture and the colour/shade prior to procurement for usage in the works.

Primer and finish paints shall be compatible with each other to avoid cracking and wrinkling. As such it is recommended that the primer and finish paint shall be from the same manufacturer.

The colour and shade shall conform to IS Standards referred to in Appendix 'D' of IS 1477-Part II. To facilitate selecting the correct shade number from the available alternatives, the Contractor shall conduct trial painting in small patches, in consultation with and as approved by the Employer's Representative.

All paint delivered to the fabrication shop/site shall be ready mixed, in original sealed containers, as packed by the manufacturer. Thinner shall not be permitted for usage unless specifically approved so by the Employer's Representative.

Paints shall be stirred thoroughly to keep the pigment in suspension.

The Contractor shall arrange for testing of paints as per relevant Indian Standards in an approved laboratory whenever the Employer's Representative requires the tests to be carried out for each batch of paints. Test results shall be submitted to the Employer's Representative for approval.

6.20.4 Workmanship

The type and the number of coats of the primer paint and finish paint shall be as specified.

Painting shall be carried out only on thoroughly dry surfaces.

No painting shall be done in frosty/foggy weather or when the humidity is high enough to cause condensation on the surface to be painted. Paint shall not be applied when the temperature of the surface to be painted is at 5deg.C or lower.

Primers shall adhere to the surface firmly and offer a key to the subsequent coats.

Workmanship shall generally conform to requirements specified in IS:1477-Part II.

It is essential to ensure that immediately after the preparation of the surfaces, the first coat of primer paint is applied by brushing and worked well to ensure a continuous film. After the first coat has dried, a second coat of primer shall be applied by brushing.

Structural steel surfaces shall be given the first coat of primer at shop and the second coat after it is erected in position. Furthermore, any abraded surfaces of the first coat that occur during transport from the shop to the site and during erection shall be provided with a touch-up coat of primer.

The dry film thickness of each coat of primer shall be not less than 25 microns.

Application of finishing paints shall be carried out within the shortest possible time interval after primer, since the primer coats are too thin to give adequate corrosion protection of the steel surface over a long duration.

Filler coats shall be applied to fill dents and to obtain a smooth finish wherever necessary. Only factory-prepared filler suitable for steel work shall be used. Fillers prepared by whiting and linseed oil by craftsmen at site shall not be used. Application of filler shall be done with good `putty knife' and necessary skill. Filler applied shall be just sufficient to fill the depression or unevenness and it shall be restricted to the minimum. It shall be applied in thin layers. In filling depression or unevenness, as many coats as are necessary may be applied allowing each layer to dry hard. The hardened coat shall be cut down by wet rubbing before

the subsequent coat is applied. Where necessary, filler coats shall be applied over the undercoats also.

Painting shall be carried out either by brushing or by spraying. The Contractor shall procure the appropriate quality of paint for this purpose as recommended by the manufacturer.

After the second coat of primer is hard dry, the entire surface shall be wet rubbed cutting down to a smooth uniform surface. When the surface becomes dry, the undercoat of paint of optimum thickness shall be applied by brushing/spraying with minimum of brush marks. The coat shall be allowed to hard-dry. The under coat shall then be wet rubbed cutting down to a smooth finish, taking adequate care to ensure that at no place the undercoat is completely removed. The surface shall then be allowed to dry.

The first finishing coat of paint shall be applied by brushing or by spraying and allowed to hard-dry. The gloss from the entire surface shall then be gently removed and the surface dusted off. The second finishing coat shall then be applied by brushing or by spraying.

At least 24 hours shall elapse between the applications of successive coats. Each coat shall vary slightly in shade and shall be approved by the Employer's Representative, prior to applying the next coat.

Minimum dry film thickness of each coat of finish paint of synthetic enamel shall be 25 microns. Minimum dry film thickness of other finish paints shall be as specified in the respective item of work.

The thickness of film shall be measured by an Elcometer to be supplied by the Contractor. The Contractor shall calibrate the Elcometer frequently for different settings. Necessary calibrating accessories should be kept ready for calibration / testing of the Elcometer at any time.

Epoxy primer and epoxy paint shall be applied within the specified pot life all as per recommendations of the manufacturer.

Surfaces inaccessible after assembly shall receive two coats of primer prior to assembly.

Surfaces inaccessible after erection, including top surfaces of floor beams, supporting grating or chequered plate shall receive one additional coat of finish paint over and above the number of coats specified prior to erection.

Portion of steel members embedded/to be encased in concrete shall not be painted. Joints to be site welded shall have no shop paint for atleast 50mm from the welding zone. Similarly, the steel surfaces shall not be painted in areas where connection is by use of friction grip bolts. On completion of the joint, the surfaces shall receive the painting as specified.

Maintenance painting of steel structures will become necessary if the painting already carried out shows signs of chalking, hairline cracking, deep checking, fine checking, peeling, blistering and rusting. It is essential that same quality of paint as specified earlier need be

adopted to ensure compatibility. The general workmanship for maintenance painting shall conform as per Clause.7 of IS 1477 – Part II.

The Contractor shall provide suitable protection as necessary to prevent paint finishes from splashing on equipment, floors, walls, etc.

6.21 Method of Measurement

For the purpose of payment, the weight of the actual, completed structures shall be calculated from the approved drawings for different items of work. Contractor shall submit to Employer relevant material list containing weight of each item.

No allowance will be permitted for weights of rivets, bolts, washers, screws etc. in calculating the weight of the completed structure. No allowances will be permitted for galvanizing, welding or for rolling margins. One tonne for the purpose of payment shall mean One Metric Tonne i.e. 1000 kg.

The weight of a member made out of standard rolled sections such as beams, channels, angles, etc. shall be based on the weight of the member given in IS 808, without deducting for hole, notches, bevel cuts, etc. Where a component consists of a cut joist or channel, the full weight of the rolled section shall be considered only if more than half the depth of the section is used. Otherwise only half the section unit weight shall be taken. Deductions shall be made in the weight of gussets/plates including chequered plates for skew cuts, notches and openings of 900 sq.cm. or larger.

For gussets/plates used in trusses, bracings, columns, beams etc. the area shall be that of the minimum circumscribing rectangle, except as stated above.

The weight of any built-up member shall be separated into the weight of each component.

Erection bolts installed by erector may be left in position on completion of erection; however, no additional payment shall be made either for supply or use of such bolts. If erection bolts are removed after erection is complete, holes shall be plug welded and ground smooth. No extra payment shall be made for such plug welding.

Painting work shall not be measured separately, if primer painting and/or primer and finish painting is deemed to be included in the scope of the item of work of fabrication and erection of structural steel since the rate per tonne of steel is deemed to include for painting as specified.

In cases where primer and/or finish painting work as specified is carried out on erected structural steel executed by a different agency, the method of measurement for painting shall be on the basis of tonnage of steel erected. For this purpose, the tonnage of erected steel as certified for payment to the different agency shall be considered as the basis and no measurement will be carried out separately.

6.22 Galvanising of Structural Steel

6.22.1 Galvanising Plant

Prior approval shall be obtained from Employer / Engineer if galvanising is proposed to be carried out outside Contractor's plant.

6.22.2 Workmanship

After all shop work is complete, all structural materials shall be punched with the erection mark and be hot-dip galvanised. Before galvanising, the steel shall be thoroughly cleaned of any paint, grease, rust, acid or alkali or such other foreign matters as are likely to interfere with the galvanising process or with the quality and durability of the zinc coating. Pickling shall be very carefully done and shall be proper.

The weight of the zinc coating shall be at least 0.610 kg/sq.m unless specified otherwise. Stub members and members for grillage type footing shall have heavier zinc coating not less than 0.80 kg/sq.m.

The galvanised surface shall consist of a continuous and uniformly thick coating of zinc, firmly adhering to the surface of steel. The finished surface shall be clean and smooth, and shall be free from defects like discoloured patches, bare spots, unevenness of coating, spelter which is loosely attached to the steel, globules, spiky IS:2633 unless specified otherwise.

All galvanised members shall be treated with Sodium dichromate solution or an approved equivalent after galvanising, so as to prevent white storage stains.

Galvanising of each member shall be carried out in one complete immersion. Double dipping shall not be permitted. However, in case of members over 7.5 M long, the Contractor shall take prior approval of Engineer for double dipping. When the steel section is removed from the galvanising kettle, excess spelter shall be removed by 'bumping'.

Wherever galvanised bolts, nuts locknuts, washers, accessories etc. are specified, they shall be hot-dip galvanised. Spring washers shall be electro-galvanised. Excess spelter from bolts, nuts, etc. shall be removed by centrifugal spinning. Rechasing of bolt threads after galvanising shall not be permitted. Nuts, however, may be tapped, but not to cause appreciable rocking of the nuts on the bolts. Readily available GI nuts, bolts and washers conforming to galvanising requirements may also be used.

Defects in certain members indicating presence of impurities in the galvanising bath in quantities larger than that permitted by the specifications, or lack of quality control in any manner in the galvanising plant, shall render the entire production in the relevant shift liable to rejection.

Contractor shall ensure that galvanising is not damaged in transit. In the event of occurrence of any damages Contractor shall at his own cost adopt scrapping and regalvanising the member to satisfy the specific requirements.

End of Chapter-6

CHAPTER 7

WATER SUPPLY AND SANITARY WORKS

CHAPTER 7

WATER SUPPLY AND SANITARY WORKS

7.1 Applicable Codes

The following standards and codes are made a part of this Employer's Requirement. All standards, codes of practice referred to herein shall be the latest editions including all official amendments and revisions.

IS : 210	:	Specification for grey iron castings
IS : 269	:	Specification for Ordinary Portland cement
IS : 383	:	Specification for coarse and fine aggregates from natural sources for concrete
IS : 432	:	Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement
IS : 456	:	Code of Practice for plain and reinforced concrete
IS : 458	:	Concrete Pipes (with and without reinforcement).
IS : 516	:	Methods of tests for strength of concrete
IS : 554	:	Dimensions for pipe threads where pressure tight joints are required on the threads.
IS : 651	:	Salt glazed stoneware pipes and fittings.
IS : 774	:	Flushing Cisterns for water closets and urinals (valveless siphonic type)
IS : 775	:	Cast iron brackets and supports for wash basins and sinks.
IS : 781	:	Sand-cast brass screw-down bib taps and stop taps for water services.
IS : 783	:	Code of practice for laying of concrete pipes.
IS : 1068	:	Electroplated coatings of nickel and chromium of iron and steel.
IS : 1077	:	Specification for common burnt clay building bricks
IS : 1786	:	Specification for high strength deformed steel bars and wires for concrete reinforcement
IS : 1239	:	Mild steel tubes (Part I) and mild steel tubulars and other wrought steel pipe fittings (Part II)
IS : 1536	:	Centrifugally cast (spun) iron pressure pipes for water, gas and sewage.
IS : 1626	:	Asbestos cement building pipes, gutters and fittings (spigot and socket types).
IS : 1703	:	Copper Alloy float valves (horizontal plunger type) for water supply purposes.
IS : 1726	:	Cast iron machine hole covers and frames.
IS : 1729	:	Sand cast iron spigot and socket soil, waste and ventilating pipes, fittings and accessories.
IS : 1742	:	Code of practice for buildings drainage
IS : 2116	:	Specification for sand for masonry mortars
IS : 2212	:	Code of practice for brickwork
IS : 2250	:	Code of practice for preparation and use of masonry mortars
IS : 2326	:	Automatic flushing cisterns for urinals
IS : 2470	:	Code of practice for design and construction of septic tanks (Parts I & II)
IS : 2556	:	Vitreous sanitary appliances (Part I to Part XV)
IS : 2963	:	Specification for copper alloy waste fittings for wash basins and sinks

IS : 3006	:	Specification for chemically resistant glazed stoneware pipes and fittings
IS : 3311	:	Waste plug and its accessories for sinks and wash basins
IS : 5455	:	Specification for cast iron steps for machine holes
IS : 4127	:	Code of Practice for laying of glazed stoneware pipes
IS : 3495	:	Methods of tests of burnt clay building bricks
IS : 4111	:	Code of practice for ancillary structures in sewerage system machine holes
IS : 5382	:	Specification for rubber sealing rings for gas mains, water mains and sewers
IS : 5329	:	Code of practice for sanitary pipe work above ground for buildings
IS : 5434	:	Non-ferrous alloy bottle traps for marine use

IS : 4985 : Specifications for Unplasticized PVC pipes for potable water supplies

IS : 7634 : Code of Practice for Plastic pipes selection, Handling, storage and installation for Potable water supplies

IS : 13592 : Specifications for Unplasticized Polyvinyl chloride pipes for soil and waste discharge system for inside and outside buildings including ventilation and rain water system

7.2 Sanitary Installation

The work shall be carried out complying in all respects with any specific requirements of the local body in whose jurisdiction the work is situated, and as approved by the Employer's Representative.

Any damage caused to the building, or to installations therein, either due to negligence on the part of the Contractor, or due to actual requirements of the work, shall be made good and the building or the installation shall be restored to its original condition by the Contractor.

All sanitary and plumbing work shall be carried out by licensed plumbers.

All sanitary appliances including sanitary fittings, fixtures, toilet requisites shall be of size, and design as approved by the Employer's Representative.

All white glazed porcelain fixtures, such as wash basin, sink drain board, water closet pan, urinal, `P' trap, etc., shall have a hard, durable, white glazed finish. They shall be free from cracks and other glazing defects. No chipped porcelain fixtures shall be used.

Joints between iron and earthenware pipes shall be made perfectly air and water tight by caulking with neat cement mortar.

7.3 Indian Type Water Closet

This shall be the long pan pattern with separate footrests made of white glazed earthenware; white glazed vitreous china or of white glazed fire clay. The general requirements shall conform to IS:2556 (Parts III and X). Each pan shall have an integral flushing rim of suitable type. It shall also have an inlet or supply horn for connecting the flush type. The flushing rim and inlet shall be of the self draining type. It shall have a weephole at the flushing inlet to the pan. The flushing inlet shall be in the

front, unless otherwise approved by the Employer's Representative. The inside of the bottom of pan shall have sufficient slope from the front towards the outlet and the surface shall be uniform and smooth enable easy and quick disposal while flushing. The exterior surface shall be unglazed and sufficiently rough or grooved at right angles to the axis of the outlet. Pans shall be provided with a trap `P' or `S' type with a minimum 50 mm water seal and 50 mm dia. vent horn. Pan shall be laid at the correct location and level over a bed of lime concrete using brick aggregates (1 part lime mortar to 2 parts brick bats with lime mortar to 2 parts of sand) or cement-sand admixture as specified in the drawings.

7.4 European Type Water Closet

Water closets shall be either of white glazed earthenware, white grazed vitreous china or white glazed fire clay as specified and shall be of "Siphonic Wash down type" conforming to IS.2556 (Part VIII). The closets shall be of one piece construction with approved plastic/bakelite seat and cover. Each water closet shall have 4 fixing holes having a minimum diameter of 6.5 mm for fixing to floor and shall have an integral flushing rim of suitable type. It shall also have an inlet of supply horn for connecting the flush pipe. The flushing rim and inlet shall be of the self-draining type. The water closet shall have a weephole at the flushing inlet.

Each water closet shall have an integral trap with either "S" or "P" outlet with at least 50 mm water seal. The water closets shall have an anti-siphonage 50 mm dia. vent horn on the outlet side of the trap. The inside of water closets and traps shall be uniform and smooth in order to ensure in efficient flush. The serrated part of the outlet shall not be glazed externally. The water closet when sealed at the bottom of the trap in line with the back plate, shall be capable of holding not less than 10 litres of water between the normal water level and the highest possible water level of the water closet installed.

7.5 Urinals

Urinals shall be of the bowl pattern, either flat back or angle back type lipped in front. They shall be of white glazed earthenware, white glazed vitreous china or white glazed fire clay, and of size as specified conforming to IS.2556 (Part VI). The urinals shall be of one piece construction. Each urinal shall be provided with not less than two fixings holes of a minimum dia. of 6.5 mm on each side. Each urinal shall have an integral flushing box rim of suitable type and inlet or supply horn for connecting the flush pipe.

The flushing rim and inlet shall be of the self-draining type. It shall have a weephole at the flushing inlet of the urinal. At the bottom of the urinal, an outlet horn for connecting to an outlet pipe shall be provided. The exterior of the outlet horn shall not be glazed and the surface shall be provided with grooves at right angles to the axis of the outlet to facilitate fixing to the uniform and smooth throughout to ensure efficient flushing. The bottom of pan shall have sufficient slope from the front, towards the outlet such that there is efficient draining of the urinal. The waste fittings shall be chromium plated.

7.6 Wash Basins

(a) Wash basins shall be of white glazed earthenware, white glazed vitreous china or white glazed fire clay as approved by the Employer's Representative and conforming to IS.2556

Type	Size
Flat Back	630 x 450 mm
Flat Back	550 x 400 mm

Wash basins shall be of one piece construction, including a combined overflow. All internal angles shall be designed so as to facilitate cleaning. Each shall have a rim sloping inside towards the bowl on all sides except skirting at the back. Basins shall be provided with single or double tap holes as approved. The tap holes shall be square. A suitable tap hole button shall be supplied if one tap hole is not required in installation. Each basin shall have a circular waste hole to which the interior of basin shall drain.

The waste hole shall be either rebated or bevelled internally with diameter of 65 mm at top and a depth of 10 mm to suit a waste plug having 64 mm diameter. Each basin shall be provided with a non-ferrous 32 mm waste fittings. Stud slots to receive the brackets on the underside of the wash basins shall be suitable for a bracket with stud not exceeding 13 mm diameter, 5 mm high and 305 mm from the back of basin to the centre of the stud. The stud slots shall be of depth sufficient to take 5 mm stud. Every basin shall have an integral soap holder recess or recesses which shall fully drain into the bowl.

The position of the chain stay-hole shall not be lower than the overflow slot. A slot type of overflow having an area of not less than 5 sq.cm. shall be provided and shall be so designed as to facilitate cleaning of the overflow. The Employer's Requirements for waste plug, chain and stay shall be the same as given for sinks.

(b) All the waste fittings shall be chromium plated. Bottle trap shall conform to IS. 5434. The chromium plating shall be of service grade No. 2 conforming to IS.1068.

7.7 Sinks

(a) The sinks shall be of white glazed earthenware, white glazed vitreous china or white glazed fire clay as approved by the Employer's Representative conforming to IS.2556 (Part V) and shall be of the following sizes:

450 x 300 x 150 mm
600 x 450 x 200 mm

(b) They shall be of one piece construction, including a combined overflow. The floor of the sink shall gently slope towards the outlet. The outlet shall in all cases be suitable for waste fittings having flange of 64 mm diameter and the waste hole shall have a minimum diameter of 65 mm at the bottom to suit the waste fittings. The waste hole shall be either rebated or bevelled having a depth of 10 mm. Each sink shall be provided with a non-ferrous 40 mm dia. waste fitting. The sink shall have overflow of the weir type and the inverts shall be 30 mm below the top edge. Each sink shall be provided with a waste plug, of suitable dia. chain and stay. The plug shall be of rubber or other equally suitable material and shall be water tight when fitted. Plug chains shall be of brass wire chromium plated. It shall have an overall length from the collar to the stay of not less than 300 mm. There shall be a triangular or D shackle at each

end, one of which shall be brazed to the plug and the other securely fixed to the stay. The 150 mm long shank of the waste shall be threaded conforming to the requirements of IS.2556 for sinks only. The waste fittings and plug fittings shall be chromium plated. The chromium plating shall be of service grade No.2 conforming to IS.1068.

7.8 Flushing Cisterns

The flushing cisterns shall be automatic or manually operated, high level or low level, as approved by the Employer's Representative. For water closets and urinals high level cistern is intended to operate with minimum height of 125 cm and a low level cistern a maximum height of 30 cm between the top of the pan and the underside of the cistern. They shall be of cast iron, glazed earthenware, or pressed steel complying iron, glazed requirement of IS.774. Automatic flushing cistern for urinals shall conform to IS.2326.

7.9 Un plasticised PVC pipes and fittings:

Un plasticised polyvinyl Chloride Pipe for Soil and Waste Discharge System for Inside and Outside Buildings Including Ventilation and Rain Water System IS 13592 and IS 14735 Specification
UPVC Injection Moulded Fittings for Soil and Waste Discharge.

Un plasticised polyvinyl chloride pipes, fittings and specials shall be to BS 3505 for portable water and BS 4346: Part 1for fitting.

The pipe shall be of the spigot and socket type with approved gasket type flexible joint. The rubber gasket shall be to BS 2494, Class C.

IS 7634 Plastic pipe selection, handling storage and installation for portable water supply.
Where PVC pipes, fittings and specifications are to be connected to cast iron, stainless steel or steel pipes, all metallic pipes, Viking Johnson type flange adopted or stepped coupling shall be used.

7.10 Stoneware pipes and fittings

All pipes with spigot and socket ends shall conform to IS.651/3006 and shall be of grade `A'. These shall be sound, free from visible defects such as fine cracks or hair cracks. The glaze of the pipes shall be free from crazing. The pipes shall give a sharp clear note when struck with a light hammer.

The following information shall be clearly marked on each pipe and fitting:

(a) Internal diameter;
(b) Grade;
(c) Date of manufacture;
(d) Name of manufacturer or his registered trade-mark or both.

All pipes and fittings shall have ISI mark.

Jointing of GSW pipes and fittings shall be done as per the requirements of the following Employer's Requirements and the relevant BIS. After jointing, extraneous material if any, shall be removed from the inside of the pipes and fittings and the newly made joints shall be thoroughly cured. In case, rubber sealing rings are used for jointing, these shall conform to IS : 5382.

7.10.1 Spigot and Socket Joint (Cement Joint)

The spigot of each pipe shall be slipped home well into the socket of the pipe previously laid and adjusted in the correct position. In each joint, spun yarn soaked in neat cement slurry or tarred gasket shall be passed around the joint and inserted in it by means of a caulking tool. More skeins of yarn or gasket shall be added if necessary and shall be well caulked. Yarn or gasket so rammed shall not occupy more than one- fourth of the depth or socket.
Cement mortar (1:1) shall be slightly moistened and carefully inserted by hand into the remaining space of the joint after caulking of yarn or gasket. The mortar shall than be caulked into the joint with a caulking tool. More cement mortar shall be added until the space of joint has been completely filled with tightly caulked mortar. The joint shall then be finished of neatly outside the socket at an angle of 45 degrees.

The cement mortar joints shall be cured at least for seven days before testing.

The approximate quantity of cement required for each joint for certain common sizes of pipes are given below for guidance:

Nominal diameter of pipe (mm)	**Cement (kg)**
150	1.5
200	2.0
250	2.5
300	3.25
350	4.5
400	5.5
450	6.5

7.10.2 Spigot and Socket Joint (Bituminous Joint)

The material for jointing shall consist of composition of asphalt and sand in the ratio of 1:7. Asphalt and sand shall be boiled together and filled into the socket in a molten state with the aid of special moulds.

7.10.3 Spigot and Socket Joint (Rubber Ring Joint)

The pipe with the rubber ring accurately positioned on the spigot shall be pushed well home into the socket of the previously laid pipe by means of uniformly applied pressure with the aid of a jack or similar appliance. The rubber rings conforming to IS : 5382 shall be used, and the manufacturer's instructions shall be deemed to form a part of this Employer's Requirements. The rubber rings shall be

lubricated before making the joint and the lubricant shall be soft soap water or an approved lubricant supplied by the manufacturer.

7.10.4 Cleaning of Pipes

As soon as a stretch of GSW pipes has been laid complete from machine hole to machine hole or for a length
as approved by the Employer's Representative, the Contractor shall run through the pipes both backward and forward a double disc or solid or closed cylinder 50 mm less in diameter than the internal diameter of pipes. The open end of an incomplete stretch of pipeline shall be securely closed as approved by the Employer's Representative to prevent entry of mud or silt etc.

If as a result of the removal of any obstruction the Employer's Representative considers that damages may have been caused to the pipe lines, he shall be entitled to order the length to be tested immediately. Should such test prove unsatisfactory the Contractor shall repair the pipeline and carry out such further tests as are required by the Employer's Representative.
It shall also be ascertained by the Contractor that each length from machine hole to machine hole or the length as approved by the Employer's Representative is absolutely clear and without any obstruction by means of visual examination of the interior of the pipeline suitably illuminated by projected sunlight or otherwise.

After laying and jointing of GSW pipes is completed the pipe line shall be tested as per the following Employer's Requirements and as approved by the Employer's Representative. All equipment for testing at work site shall be supplied and erected by the Contractor. Water for testing of pipeline shall be arranged by him. Damage during testing shall be the Contractor's responsibility and shall be rectified by him to the full satisfaction of the Employer's Representative. Water used for test shall be removed from pipes and not released to the excavated trenches.

After the joints have thoroughly set and have been checked by the Employer's Representative and before backfilling the trenches, the entire section of the sewer or storm water drain shall be proved by the Contractor to be water tight. Before commencing the hydraulic test, the pipelines shall be filled with water and maintained full for 24 hours by adding water, if necessary, under a head of 0.6 m of water. The test shall be carried out by suitably plugging the low end of the drain and the ends of connections, if any, and filling the system with water.

A knuckle bend shall be temporarily jointed at the top end and a sufficient length of vertical pipe jointed to it so as to provide the required test head; or the top end may be plugged with a connection to a hose ending in a funnel which could be raised or lowered till the required head is obtained and fixed suitably for observation. The pipeline shall be subjected to a test pressure of at least 2.5 m head of water at the highest point of the section under test. The tolerance of two litres per centimeter of diameter per kilometer may be allowed during a period of 10 minutes. Any leakage including excessive sweating which causes a drop in the test water level will be visible and the defective part of the work should be removed and made good.

If any damage is caused to the pipeline during the execution of work or while cleaning/testing the pipeline as specified. The Contractor shall be held responsible for the same and shall replace the damaged pipeline and re-test the same to the full satisfaction of the Employer's Representative.

Water for testing of pipeline shall be arranged by the Contractor.

7.11 Stop Cock and Bib Cock

A bibcock (bibtap) is a draw off tap with a horizontal inlet and free outlet and stopcock (stop tap) is a valve with a suitable means of connections for insertion in a pipe line for controlling or stopping the flow. They shall be of specified size and shall be of the screw down type. The closing device should work by means of a disc carrying a renewable non-metallic washer, which shuts against water pressure on a seating at right angles to the axis of the threaded spindle which operates it. The handle shall be either crutch or butterfly type securely fixed to the spindle. The cocks shall open in anti-clockwise direction. When the bib cocks and stop cocks are required to be chromium plated, the chromium plating shall be of service Grade No. 2 conforming to IS.1068. in finish and appearance, the plated articles shall be free from plating defects such as blisters, pits, roughness and shall not be stained or discoloured.

These fittings shall be of brass heavy class, chromium plated (C.P) and of approved manufacture and pattern with screwed of flanged ends as specified. The fittings shall in all respects comply with the requirements of IS.781. The standard size of brass fittings shall be designated by the nominal bore of the pipe to which the fittings are attached. A sample of each kind of fitting shall be approved by the Employer's Representative and all supplies made according to the approved samples.

All cast fittings shall be sound and free from laps, blow holes and fittings, both internal and external surfaces shall be clean, smooth and free from sand etc. Burning, plugging stopping or patching of the casting shall not be permitted. The bodies, bonnets, spindles and other parts shall be truly machined and when assembled the parts shall be axial, parallel and cylindrical with surfaces smoothly finished. The area of the waterway of the fittings shall not be less than the area of the nominal bore.

The fittings shall be fully examined and cleared of all foreign matter before being fixed. The fittings shall be fitted in the pipe line in a workman like manner. The joints between fittings and pipes shall be made leak- proof. The joints and fittings shall be leak proof when subjected to a pressure test approved by the Employer's Representative and the defective fittings and joints shall be replaced or redone.

7.12 Soak Pit

Soak pit shall be constructed at the location specified by the Employer's Representative. Earthwork excavation shall be carried out to the exact dimensions. Brick masonry lining with open joints shall be constructed in the pit upto 150 mm below the outlet pipeline. Brick masonry in cement mortar 1:6 shall be constructed above this level upto ground. Well burnt brick aggregates of nominal size 40 mm to 80 mm and coarse sand shall be filled within the chamber. Construction of pit lining and filling of the brick ballast shall progress simultaneously.

7.13 Machine holes

7.13.1 Location

Machine holes shall be constructed at places approved by the Employer's Representative.

7.13.2 Excavation

Excavation, shoring, dewatering etc. for the pits of machine holes, laying of pipes and fittings/specials shall be done in accordance with Employer's Requirements described elsewhere in the document.

7.13.3 Bed Concrete

The bed concrete for machine holes shall be done in accordance with Employer's Requirements described elsewhere in the document.

7.13.4 Bricks

Bricks used for construction of machine holes shall conform to the relevant Indian Standards. They shall be Wire cut bricks/ Table moulded type, sound, hard, homogeneous in texture, well burnt in kiln without being vitrified, deep red, cherry or copper coloured, of regular shape and size and shall have sharp and square and parallel faces. The bricks shall be free from pores, chips, flaws or humps of any kind. Bricks containing ungrounded particles and/or which absorb water more than 1/6th of their weight when soaked in water for twenty-four hours shall be rejected. Over burnt or under burnt bricks shall be liable to rejection. The bricks shall give a clear ringing sound when struck and shall have a minimum crushing strength of 50 kg/sq.cm. unless otherwise noted in drawings. The class and quality requirements of bricks shall be as laid down in IS : 1077.

The size of the brick shall be 23.0 x 11.5 x 7.5 cm. unless otherwise specified; but tolerance upto ± 3 mm in each direction shall be permitted. Only full size brick shall be used for masonry work. Brick bats shall be used only with the permission of Employer's Representative to make up required wall length or for bonding. Sample bricks shall be submitted to the Employer's Representative for approval and bricks supplied shall conform to approved samples. If required by the Employer's Representative, brick sample shall be tested as per IS : 3495 by Contractor. Bricks rejected by the Employer's Representative shall be removed from the Site within 24 hours.

7.13.5 Cement Mortar

Mortar for brick masonry shall be prepared as per IS : 2250. Machine holes shall be constructed in brick masonry with cement mortar (1:2) unless otherwise specified. Guage boxes for sand shall be of such dimensions that one bag containing 50 kg. of cement forms one unit. The sand shall be free from clay, shale, loam, alkali and organic matter and shall be of sound, hard, clean and durable particles. Sand shall be as approved by the Employer's Representative. If required by the Employer's Representative sand shall be thoroughly washed till it is free of any contamination.

For preparing cement mortar, the ingredients shall first be mixed thoroughly in dry conditions. Water shall then be added and mixing continued to give a uniform mix of required consistency. Cement mortar shall be used within 25 minutes of mixing. Mortar left unused in the specified period shall be rejected.

The Contractor shall arrange for tests on mortar samples if so required by Employer's Representative. Retempering of mortar shall not be permitted.

7.13.6 Brick Masonry

All bricks shall be thoroughly soaked in clean water for at least one hour immediately before being laid. Brick work 230 mm thick and over shall be laid in English Bond unless otherwise specified. 115 mm thick brick work shall be laid with stretchers. For laying bricks, a layer of mortar shall be spread over the full width of suitable length of the lower course. Each brick shall be pressed into the mortar and shoved into final position so as to embed the brick fully in mortar. Bricks shall be laid with frogs uppermost.

All brickwork shall be plumb and square unless otherwise shown on drawing and true to dimensions shown. Vertical joints in alternate courses shall come directly one over the other and be in line. Horizontal courses shall be levelled. The thickness of brick courses shall be kept uniform. For walls of thickness greater than 230 mm both faces shall be kept in vertical planes unless otherwise specified.

All interconnected brickwork shall be carried out at nearly one level (so that there is uniform distribution of pressure on the supporting structure) and no portion of the work shall be left more than one course lower than the adjacent work. Where this is not possible, the work shall be raked back according to bond (and not saw toothed) at an angle not exceeding 45 degrees. But in no case the level difference between adjoining walls shall exceed 1.25 M. Workmanship shall conform to IS : 2212.

Brick shall be so laid that all joints are well filled with mortar. The thickness of joints shall not be less than 6 mm and not more than 10 mm. The face joints shall be raked to a minimum depth of 12 mm by raking tools daily during the progress of work when the mortar is still green, so as to provide a proper key for the plastering to be done. When plastering is not required to be done, the joints shall be uniform in thickness and be struck flush and finished at the time of laying. The face of brickwork shall be cleaned daily and all mortar droppings removed. The surface of each course shall be thoroughly cleaned of all dirt before another course is laid on top. If mortar in the lower courses has begun to set, the joints shall be raked out to a depth of 12 mm before another course is laid.

7.13.7 Cement Plaster

All joints in masonry shall be raked to a depth of 12 mm with hooked tool made for the purpose when the mortar is still green and in any case within 48 hours of its laying. The surface to be rendered shall be washed with fresh clean water free from all dirt, loose material, grease etc. and thoroughly wetted for 6 hours before plastering work is commenced. Concrete surfaces to be rendered will however be kept dry. The wall should not be too wet but only damp at the time of plastering. The damping shall be uniform to get uniform bond between the plaster and the wall.

The proportion of the cement mortar shall be as approved on relevant drawings. Cement shall be mixed thoroughly in dry condition and then just enough water added to obtain a workable consistency. The quality of water, sand and cement shall be as per relevant I.S. The mortar thus mixed shall be used immediately and in no case shall the mortar be allowed to remain for more than 25 minutes after mixing with water.

Curing of plaster shall be started as soon as the applied plaster has hardened enough so as not to be damaged. Curing shall be done by continuously applying water in a fine spray and shall be carried out for at least 7 days.

Plastering shall be done on both faces of brick masonry in cement mortar (1:2) and 20 mm thick unless otherwise specified.

Plastering work shall be carried out in two layers, the first layer being 14 mm thick and the second layer being 6 mm thick. The first layer shall be dashed against the prepared surface with a trowel to obtain an even surface. The second layer shall then be applied and finished leaving an even and uniform surface, trowel finished unless otherwise approved by the Employer's Representative.

7.13.8 Cement Concrete Channel

The channel for the machine hole shall be constructed in cement concrete of M15 grade. Both sides of the channel shall be taken up to the level of the crown of the outgoing sewer. They shall be benched up in concrete and rendered in cement mortar (1:1) of 20 mm thickness and formed to a slope of 1 in 12 towards the channel.

7.13.9 Pipe Entering or Leaving Machine hole

Whenever a pipe enters or leaves a machine hole, bricks on edge must be cut to a proper form and laid around the upper end of the pipe so as to form an arch. All around the pipes, there shall be a joint of cement mortar (1:2) 13 mm thick between it and the bricks.

7.13.10 PVC encapsulated Rungs

Rungs shall meet the dimensions as specified in IS : 5455. Material shall be in Fe415 or Fe500 plastic encapsulated. The steps shall be clean, well cast and they shall be free from air and sand holes, cold shuts and warpings. The portion of the step which projects from the wall of the machine hole shall have adequate non-slip grip.

Where the depth of invert of machine hole exceeds 800 mm, the steps of approved pattern shall be fixed in the brick work or RCC at the interval of 300 mm vertically and staggered at 380 mm horizontally centre to centre. In case of pipe diameter greater than 600 mm, box type steps shall be provided at 300 mm vertically in channel of machine hole.

7.13.11 Frame and Covers

Frame and covers for machine holes shall be of required type and dimensions as per the relevant drawings prepared by the Contractor. Following information shall be clearly marked on each cover.
Year of manufacture,
Identification mark of the purchaser,
SEWERS/SWD,
Arrow showing direction of flow

7.13.11.1 Cast Iron Frame and Cover

The cast iron frame and cover shall be of grey cast iron as per IS : 1726. The general requirements for casting and coating of CI frame and cover shall be as specified for CI steps in Clause 7.15.10. The covers shall have a raised chequered design to provide an adequate non-slip grip. The rise of the chequer shall be not less than 4 mm. The locking device for the cover shall be provided as approved

by the Employer's Representative. The CI covers for the load test shall be selected at one for every lot of fifty or part thereof for each type and size manufactured and as approved by the Employer's Representative. The frame shall be fixed in cement concrete of M15 grade all round and finished with neat cement. The machine hole frame shall have 560 mm diameter clear opening and shall weigh not less than 208 kg. including cover. In case of rectangular CI frame and cover of 900 mm x 600 mm clear opening, the total weight shall not be less than 275 kg. In case of scraper machine hole the frame shall have clear opening of 1200 mm x 900 mm and shall weigh not less than 900 kg including cover. The machine hole cover and frame shall be painted with three coats of anti-corrosive paint after fixing in position.

7.13.11.2 Fibre Reinforced Concrete Frame and Cover

Fibre reinforced concrete frame and cover shall be capable of withstanding load of 35 tonnes. The frame shall be fixed in cement concrete of M15 grade all around and finished with neat cement. The fibre reinforced frame shall have clear opening of 560 mm diameter and weighing 102 kg. The cover shall have a minimum thickness of 100 mm and weighing 78 kg. The fibres shall constitute 1% of the weight of the concrete in the form of 50 mm to 100 mm long high tensile steel wires. For the cover, MS sheet lapping of 18 gauge shall be provided to avoid damage to the edges. Similarly for frame, MS angle/flat shall be provided along the edge. Both MS sheet and angle shall be painted with black bituminous paint. The cover should have suitable lifting arrangement. The fibre reinforced frame and cover shall be manufactured as approved.

7.13.11.3 Reinforced Cement Concrete Frame and Cover

Reinforced cement concrete frame and cover for machine holes shall be of required dimensions and shape as shown on the drawing prepared by the Contractor. The frame and cover shall be cast in cement concrete of M25 grade. Minimum cover to the reinforcement shall be 40 mm. The edges of frame and covers shall be provided with mild steel angles to avoid damages to the corners. These angles shall be painted with black bituminous paint. The covers should have suitable lifting arrangement.

7.13.12 Drop Machine hole

When a sewer connects a main sewer, and where the difference in level between water line (peak flow levels) of main line and the invert level of branch lines is more than 600 mm or a drop of more than 600 mm is required to be given in the same sewer line and it is uneconomical or impractical to arrange the connection within 600 mm, a drop connection shall be provided for which a machine hole shall be constructed as per relevant drawing, incorporating a vertical drop pipe from the higher sewer to the lower one. This pipe shall be provided outside the shaft and encased in concrete. A continuation of the branch sewer should be built through the shaft wall to form a rodding and inspection eye, which should be provided with a half blank flange. The diameter of the back drop should be at least as large as that of the incoming pipe. The drop pipe should terminate at its lower end with a plain or duck-foot bend turned so as to discharge its flow at 45 degrees or less to the direction of the flow in the main sewer. The pipe unless of cast iron should be surrounded with 150 mm thick concrete.

In the case of sewers over 450 mm in diameter the drop in level may be accomplished by one of the following approved methods:

(a) A cascade;

(b) A ramp;
(c) By drops in previous machine holes.

7.13.13 RCC Machine hole

M30 grade of concrete used for construction of RCC machine hole shall have minimum cement content of 400 kg/cum of concrete. Minimum cover to the reinforcement shall be 50 mm.

7.13.14 Vent Shafts

7.13.14.1 General

Vent shafts shall be erected at such places as approved by the Employer's Representative.

7.13.14.2 Mild Steel Vent Shaft

Mild steel vent shaft shall be of 150 mm diameter and 12.17 m height from ground level with C.I. ornamental cap. This shall be fixed firmly and encased in cement concrete of M15 grade as shown on relevant drawing with necessary mild steel bolts, plates etc. for foundation. The vent shaft shall be painted with one coat of silver paint over one coat of red lead oxide paint. The vent shaft shall be connected to machine hole by 150 mm diameter glazed stoneware pipe encased by M10 concrete of 150 mm thickness all around as approved by the Employer's Representative.

7.13.14.3 RCC Vent Shaft

Reinforced cement concrete vent shaft shall be of M30 grade concrete, 200 mm diameter at bottom and tapered to 100 mm diameter at top (both inside clear openings) and 6 m height from ground level. The vent shaft shall be embedded in concrete of M10 grade and anchored by 2 nos. of 16 mm diameter and 600 mm long MS bars. The vent shaft shall be connected to machine hole as specified in (b) above through a brick masonry flue chamber.

7.13.15 Miscellaneous

If any damage is caused to the other services such as water supply pipeline, sewer, cable, etc. during the construction of machine holes and erection of vent shafts, the Contractor shall be held responsible for the same and shall replace the damaged services to the full satisfaction of the Employer's Representative.

The interior of machine holes shall be cleared of all debris after construction and before testing the same for water tightness by the Contractor.

7.14 Measurement for Pipes

AC, Cast iron and S.W. drainage pipes shall be measured along the centrelines of pipes including all fittings such as junctions, plug bends etc., for which no separate payment shall be made.

GI pipes with fittings completely fixed in position shall be measured and paid for the finished centreline lengths, including all fittings such as tees, bends, couplings etc., for which no separate payment shall be made.

In measuring the lengths of sewer pipes laid, length between faces of machine holes shall be considered. Inspection chambers shall only be measured omitting lengths of channels between inside faces of walls of machine holes of chambers.

End of Chapter-7

CHAPTER 8

GENERAL CIVIL WORKS

CHAPTER 8

GENERAL CIVIL WORKS

8.1 Applicable Codes and Specifications

The following codes and standards are included in this Chapter.

IS:110 - Ready mixed paint, brushing, grey filler, for enamels for use over primers

IS:269 - Specification for Ordinary Portland cement

IS:280 - Specification for mild steel wire for general engineering purposes

IS:287 - Recommendations for maximum permissible moisture content of timber used for different purposes

IS: 304 - High Tensile Brass Ingots and Castings.

IS:337 - Varnish, finishing interior

IS:348 - French polish

IS:383 - Specification for coarse and fine aggregates from natural sources for concrete

IS:412 - Expanded metal steel sheets for general purposes

IS:419 - Specification for putty for use on window frames

IS:428 - Distemper, oil emulsion, colour as required

IS:459 - Specification for unreinforced corrugated and semi-corrugated asbestos cement sheets

IS:702 - Specification for industrial bitumen

IS:710 - Specification for marine plywood

IS:712 - Specification for building limes

IS:730 - Specification for hook bolts for corrugated sheet roofing

IS:733 - Wrought aluminium and aluminium alloys, bars, rods and sections for general engineering purposes

IS:777 - Specification for glazed earthenware tiles

IS:1003 - Specification for timber panelled and glazed shutters (Parts 1 & 2)

IS:1038 - Specification for steel doors, windows and ventilators

IS:1077 - Specification for common burnt clay building bricks

IS:1081 - Code of practice for fixing and glazing of metal (steel & aluminium) doors, windows and ventilators

IS:1124	-	Method of test for determination of water absorption, apparent specific gravity and porosity of natural building stones
IS:1237	-	Specification for cement concrete flooring tiles
IS:1322	-	Bitumen felts for water proofing and damp proofing
IS:1346	-	Code of practice for water proofing of roofs with bitumen felts
IS:1361	-	Specification for steel windows for industrial buildings
IS:1397	-	Specification for kraft paper
IS:1443	-	Code of practice for laying and finishing of cement concrete flooring tiles
IS:1477	-	Code of practice for painting of ferrous metals in buildings (Parts 1 & 2)
IS:1542	-	Specification for sand for plaster
IS:1580	-	Specification for bituminous compounds for water-proofing and caulking purposes
IS:1597	-	Code of practice for construction of stone masonry: Part 1 Rubble stone masonry
IS:1659	-	Specification for block boards
IS:1661	-	Code of practice for application of cement and cement-lime plaster finishes
IS:1834	-	Specification for hot applied sealing compound for joint in concrete
IS:1838	-	Specification for preformed fillers for expansion joint in concrete pavements and structures (non extruding and resilient type): Part 1 Bitumen impregnated fibre
IS:1948	-	Specification for aluminium doors, windows and ventilators
IS:1949	-	Specification for aluminium windows for industrial buildings
IS:2074	-	Ready mixed paint, air drying, red oxide- zinc chrome, priming
IS:2098	-	Asbestos cement building boards
IS:2114	-	Code of practice for laying in-situ terrazzo floor finish
IS:2116	-	Specification for sand for masonry mortars
IS:2185	-	Specification for concrete masonry units (Parts 1,2 & 3)
IS:2202	-	Specification for wooden flush door shutters (Solid core type) : Parts 1 & 2
IS:2212	-	Code of practice for brickwork
IS:2250	-	Code of practice for preparation and use of masonry mortars
IS:2338	-	Code of practice for finishing of wood and wood-based materials (Parts 1 & 2)

IS:2339	-	Aluminium paint for general purposes, in dual container
IS:2395	-	Code of practice for painting concrete, masonry and plaster surfaces (Parts 1 & 2)
IS:2402	-	Code of practice for external rendered finishes
IS:2571	-	Code of practice for laying in-situ cement concrete flooring
IS:2645	-	Specification of integral cement waterproofing compounds
IS:2690	-	Specification for burnt clay flat terracing tiles: Part 1 Machine made
IS:2691	-	Specification for burnt clay facing bricks
IS:2750	-	Specification for steel scaffoldings
IS:2835	-	Flat transparent sheet glass
IS:2932	-	Specification for enamel, synthetic, exterior type (a) undercoating, (b) finishing
IS:3007	-	Code of practice for laying of asbestos cement sheets - corrugated and (Part 1 & 2) semi-corrugated sheets
IS:3036	-	Code of practice for laying lime concrete for a water-proofed roof finish
IS:3067	-	Code of practice of general design details and preparatory work for damp-proofing and water- proofing of buildings
IS:3068	-	Specification for broken brick (burnt clay) coarse aggregates for use in lime concrete
IS:3384	-	Specification for bitumen primer for use in water-proofing and damp-proofing
IS:3461	-	Specification for PVC-asbestos floor tiles
IS:3462	-	Specification for unpacked flexible PVC flooring
IS:3495	-	Method of test for burnt clay building bricks: Part 1 to 4
IS:3536	-	Specification for ready mixed paint, brushing, wood primer, pink
IS:3564	-	Specification for door closers (hydraulically regulated)
IS: 3614 (Part – 1)	-	Specification for fire checks doors: Part –I Plate metal covered and rolling type
IS: 3614 (Part – 2)	-	Specification for metallic and non-metallic fire check doors: Part-2 Resistance test and performance criteria
IS:3696	-	Safety code of scaffolds and ladders (Parts 1 & 2)

IS:4020	-	Methods of test for wooden flush door: Type test
IS:4021	-	Specification for timber door, window and ventilator frames
IS:4351	-	Specification for steel door frames
IS:4443	-	Code of practice for use of resin type chemical resistant mortars
IS:4457	-	Specification for ceramic unglazed vitreous acid resisting tile
IS:4631	-	Code of practice for laying epoxy resin floor toppings
IS:4832	-	Specification for chemical resistant mortars (Part II)
IS:4860	-	Specification for acid resistant bricks
IS:4948	-	Specification for welded steel wire fabric for general use
IS:5318	-	Code of practice for laying of flexible PVC sheet and tile flooring
IS:5410	-	Cement paint, colour as required
IS:5411	-	Specification for plastic emulsion paint (Parts 1 & 2)
IS:5437	-	Wired and figured glass
IS:5491	-	Code of practice for laying of in-situ granolithic concrete floor topping
IS:6041	-	Code of practice construction of autoclaved cellular concrete block masonry
IS:6042	-	Code of practice for construction of light weight concrete block masonry
IS:6248	-	Specification for metal rolling shutters and rolling grilles
IS:7193	-	Specification for glass fibre base coal tar pitch and bitumen felts
IS:7452	-	Specification for hot rolled steel sections for doors, windows and ventilators
IS:8042	-	Specification for white Portland cement
IS:8543	-	Methods of testing plastics
IS:8869	-	Specification for washers for corrugated sheet roofing
IS: 9197	-	Specification for epoxy resin, hardeners and epoxy resin composites for floor topping
IS:9862	-	Specification for ready mixed paint, brushing, bituminous, black, lead-free, acid, alkali, water and chlorine resisting
IS:12200	-	Code of practice for provision of waterstops at transverse contraction joints in masonry and concrete dams

BS: 476 (Part – 20)	-	Methods for determination of the fire resistance of elements of construction (General Principles)
BS: 476 (Part – 21)	-	Methods for determination of the fire resistance of load bearing elements of construction
BS: 476 (Part – 22)	-	Methods for determination of the fire resistance of non-load bearing elements of construction
Part – IV	-	National Building code of India (Fire Protection)

8.2 Brickwork

8.2.1 Materials

Bricks used in the works shall conform to the requirements laid down in IS: 1077. The class of the bricks shall be as specifically indicated in the respective items of work.

The nominal size of the modular brick shall be 200 mm x 100 mm x 100 mm with the permissible tolerances over the actual size of 190 mm x 90 mm x 90 mm as per IS: 1077. The nominal thickness of one brick and half brick walls using modular bricks shall be considered as 200 mm and 100 mm respectively. In the event of use of traditional bricks of nominal size 230 mm x 115 mm x 75 mm with a tolerance of up to 3 mm in each dimension, one brick and a half brick walls shall be considered as 230 mm and 115 mm respectively.

Bricks shall be sound, hard, homogenous in texture, well burnt in kiln without being vitrified, hand/machine moulded, deep red, cherry or copper coloured, of regular shape and size & shall have sharp and square edges with smooth rectangular faces. The bricks shall be free from pores, cracks, flaws and nodules of free lime. Hand moulded bricks shall be moulded with a frog and those made by extrusion process may not be provided with a frog. Bricks shall give a clear ringing sound when struck and shall have a minimum crushing strength of 5N/sq.mm unless otherwise specified in the items of work.

The average water absorption shall not be more than 20 percent by weight upto class 12.5 and 15 percent by weight for higher classes. Bricks which do not conform to this requirement shall be rejected. Over or under burnt bricks are not acceptable for use in the works.

Sample bricks shall be submitted to the Engineer for approval and bricks supplied shall conform to approved samples. If demanded by Engineer, brick samples shall be got tested as per IS: 3495 by Contractor. Bricks rejected by Engineer shall be removed from the site of works within 24 hours.

Mortar for brick masonry shall consist of cement and sand and shall be prepared as per IS: 2250. Mix shall be in the proportion of 1:5 for brickwork of thickness one brick or above and 1:4 for brickwork of thickness half brick or below, unless otherwise specified in the respective items of work. Sand for masonry mortar shall conform to IS: 2116. The sand shall be free from clay, shale, loam, alkali and organic matter and shall be of sound, hard, clean and durable particles. Sand

shall be approved by Engineer. If so directed by the Engineer, sand shall be screened and washed till it satisfies the limits of deleterious materials.

For preparing cement mortar, the ingredients shall first be mixed thoroughly in dry condition. Water shall then be added and mixing continued to give a uniform mix of required consistency. Mixing shall be done thoroughly in a mechanical mixer, unless the Engineer specifically permits hand mixing. The mortar thus mixed shall be used as soon as possible, preferably within 30 minutes from the time water is added to cement. Incase, the mortar has stiffened due to evaporation of water, this may be re-tempered by adding water as required to restore consistency, but this will be permitted only upto 30 minutes from the time of initial mixing of water to cement. Any mortar which is partially set shall be rejected and shall be removed forthwith from the site. Droppings of mortar shall not be re-used under any circumstances.

The Contractor shall arrange for test on mortar samples if so directed by the Engineer.

8.2.2 Workmanship

Workmanship of brick work shall conform to IS: 2212. All bricks shall be thoroughly soaked in clean water for at least one hour immediately before being laid. The cement mortar for brick masonry work shall be as specified in the respective item of work. Brick work 200mm/230mm thick and over shall be laid in English Bond unless otherwise specified. 100mm/115mm thick brickwork shall be laid with stretchers. For laying bricks, a layer of mortar shall be spread over the full width of suitable length of the lower course. Each brick shall be slightly pressed into the mortar and shoved into its final position so as to embed the brick fully in the mortar. Only full-size bricks shall be used for the works and cut bricks utilised only to make up required wall length or for bonding. Bricks shall be laid with frogs uppermost.

All brickwork shall be plumb, square and true to dimensions shown. Vertical joints in alternate courses shall come directly one over the other and be in line. Horizontal courses shall be levelled. The thickness of brick courses shall be kept uniform. In case of one brick thick or half brick thick wall, atleast one face should be kept smooth and plane, even if the other is slightly rough due to variation in size of bricks. For walls of thickness greater than one brick both faces shall be kept smooth and plane. All interconnected brickwork shall be carried out at nearly one level so that there is uniform distribution of pressure on the supporting structure and no portion of the work shall be left more than one course lower than the adjacent work. Where this is not possible, the work shall be raked back according to bond (and not saw toothed) at an angle not exceeding 45 deg. But in no case the level difference between adjoining walls shall exceed one metre. Brick work shall not be raised more than one metre per day.

Bricks shall be so laid that all joints are well filled with mortar. The thickness of joints shall not be less than 6 mm and not more than 10 mm. The face joints shall be raked to a minimum depth of 10mm/15mm by raking tools during the progress of work when the mortar is still green, so as to provide a proper key for the plastering/ pointing respectively to be done later. When plastering or pointing is not required to be done, the joints shall be uniform in thickness and be struck flush and finished at the time of laying. The face of brickwork shall be cleaned daily and all mortar droppings removed. The surface of each course shall be thoroughly cleaned of all dirt before another course is laid on top.

During inclement weather conditions, newly built brick masonry works shall be protected by tarpaulin or other suitable covering to prevent mortar being washed away by rain.

Brickwork shall be kept constantly moist on all the faces for at least seven days after 24 hrs of laying. The arrangement for curing shall be got approved from the Engineer.

Double scaffolding having two sets of vertical supports shall be provided to facilitate execution of the masonry works. The scaffolding shall be designed adequately considering all the dead, live and possible impact loads to ensure safety of the workmen, in accordance with the requirements stipulated in IS:2750 and IS:3696 (Part I). Scaffolding shall be properly maintained during the entire period of construction. Single scaffolding shall not be used on important works and will be permitted only in certain cases as decided by the Engineer. Where single scaffolding is adopted, only minimum number of holes, by omitting a header shall be left in the masonry for supporting horizontal scaffolding poles. All holes in the masonry shall be carefully made good before plastering/pointing.

In the event of usage of traditional bricks of size 230 mm x115mm x75mm, the courses at the top of the plinth and sills as well as at the top of the wall just below the roof/floor slabs and at the top of the parapet shall be laid with bricks on edge.

All brickwork shall be built tightly against columns, floor slabs or other structural members.

To mitigate the risk of developing cracks in the brick masonry, the following measures shall be implemented.

For resting RCC slabs, the bearing surface of the masonry wall shall be finished on top with 12 mm thick cement mortar 1:3 and provided with two layers of Kraft paper Grade 1 as per IS:1397 or two layers of 50 micron thick polyethylene sheets.

RCC/steel beams resting on a masonry wall shall be provided with reinforced concrete bed blocks of 50 mm thickness, projecting 50 mm on either side of the beam, duly finished on top with two layers of Kraft paper Grade 1 as per IS:1397 or two layers of 50 micron thick polyethylene sheets.

Steel wire fabric shall be provided at the junction of brick masonry and concrete before taking up plastering work.

Bricks for partition walls shall be stacked adjacent to the structural member to pre-deflect the structural member before the wall is taken up for execution. Further, the topmost course of half or full brick walls abutting against either a de-shuttered slab or beam shall be built only after any proposed masonry wall above the structural member is executed to cater for the deflection of the structural element.

Reinforced cement concrete transoms and mullions of dimensions as indicated in the construction Drawings are generally required to be provided in the half brick partition walls.

Where the drawings indicate that structural steel sections are to be encased in brickwork, the brick masonry shall be built closely against the steel section, ensuring a minimum of 20 mm thick cement-sand mortar 1:4 over all the steel surfaces. Steel sections partly embedded in brickwork shall be provided with bituminous protective coating to the surfaces at the point of entry into the brick masonry.

Contractor shall note that the unit rates quoted for the masonry work shall be deemed to include for the installation of miscellaneous inserts such as pipe sleeves, bolts, steel sections with anchors etc. and provide pockets, leaving openings, cutting chases etc. in accordance with the

construction drawings. Miscellaneous inserts shall be either supplied free by the Employer or to be furnished by the Contractor. Any of the miscellaneous inserts which are required to be fabricated and supplied by the Contractor and cement concrete to be provided in the pockets for holdfasts of door/window frames etc. shall however, be measured and paid for separately under the respective items of work.

Facing bricks of the type specified conforming to IS: 2691 shall be laid in the positions indicated on the drawings and all facing brickwork shall be well bonded to the backing bricks/RCC surfaces. The level of execution of the facing brick work shall at any time be lower by at least 600 mm below the level of the backing brickwork.

Facing bricks shall be laid over 10 mm thick backing of cement mortar. The mortar mix, thickness of joint and the type of pointing to be carried out shall be as specified in the item of works. The pattern of laying the bricks shall be as specifically indicated in the drawings.

For facing brickwork, double scaffolding shall be used.

Faced works shall be kept clean and free from damage, discoloration etc., at all times.

8.2.3 Measurement

Measurement shall be in cu. m correct to two places of decimal for brickwork of thickness one brick i.e. 200 mm/230 mm and above. Measurement shall be in sq. m correct to two places decimal for facing brickwork and brickwork of thickness half brick i.e. 100mm/115mm and below. Measurement shall be for the quantities as actually executed duly deducting for openings, lintels, transoms / mullions etc. All concrete works shall be measured and paid for separately under the respective items of work.

8.3 Uncoursed Random Rubble Masonry in Foundation, Plinth and Superstructure

8.3.1 Materials

Stones for the works shall be of the specified variety which is hard, durable, fine grained and uniform in colour (for superstructure work) free from veins, flaws and other defects. Quality and work shall conform to the requirements specified in IS:1597 (Part-I). The percentage of water absorption shall not exceed 5 percent as per test conducted in accordance with IS: 1124. The Contractor shall supply sample stones to the Engineer for approval. Stones shall be laid with its grains horizontal so that the load transmitted is always perpendicular to the natural bed.

Cement-sand mortar for stone masonry works shall be in the proportion of 1:6. Materials and preparation of mortar shall be as specified in clause 8.2.1.

8.3.2 Workmanship

For all works below ground level, the masonry shall be random rubble uncoursed with ordinary quarry-dressed stones for the hearting and selected quarry-dressed stones for the facing.

For all works above ground level and in superstructure, the masonry shall be random rubble uncoursed, well bonded, faced with hammer-dressed stones with squared quoins at corners. The bushings on the face shall not be more than 40 mm on an exposed face and on the face to be plastered it shall not project by more than 12 mm nor shall it have depressions more than 10 mm from the average wall surface.

Face stones shall extend back sufficiently and bond well with the masonry. The depth of stone from the face of the wall inwards shall not be less than the height or breadth at the face. The length of the stone shall not exceed three times the height and the breadth on base shall not be greater than three-fourths the thickness of wall nor less than 150 mm. The height of stone may be up to a maximum of 300 mm. Face stones or hearting stones shall not be less than 150 mm in any direction.

Chips and spalls shall be used wherever necessary to avoid thick mortar joints and to ensure that no hollow spaces are left in the masonry. The use of chips and spalls in the hearting shall not exceed 20 percent of the quantity of stone masonry. Spalls and chips shall not be used on the face of the wall and below hearting stones to bring them to the level of face stones.

The maximum thickness of joints shall not exceed 20 mm. All joints shall be completely filled with mortar. When plastering or pointing is not required to be done, the joints shall be struck flush and finished as the work proceeds. Otherwise, the joints shall be raked to a minimum depth of 20 mm by a raking tool during the progress of the work while the mortar is still green.

Through or bond stones shall be provided in walls up to 600 mm thick and in case of walls above 600 mm thickness, a set of two or more bond stones overlapping each other by at least 150 mm shall be provided in a line from face to back. In case of highly absorbent types of stones (porous limestone and sandstone, etc.), the bond stone shall extend about two-thirds into the wall, and a set of two or more bond stones overlapping each other by at least 150 mm shall be provided. Each bond stone or a set of bond stones shall be provided for every 0.5 sq. m of wall surface.

All stones shall be sufficiently wetted before laying to prevent absorption of water from the mortar. All connected walls in a structure shall be normally raised uniformly and regularly. However, if any part of the masonry is required to be left behind, the wall shall be raked back (and not saw toothed) at an angle not exceeding 45 degrees. Masonry work shall not be raised by more than one metre per day.

Green work shall be protected from rain by a suitable covering. Masonry work shall be kept constantly moist on all the faces for a minimum period of seven days for proper curing of the joints.

Type of scaffolding to be used shall be as specified in clause 8.2.2.

8.3.3 Measurement

Measurement shall be in cu. m correct to two places of decimal. The quantities measured and paid for, shall be those as actually executed after making necessary deductions for openings, lintels etc.

8.4 Coursed Rubble Masonry (First Sort) for Superstructure

8.4.1 Materials

The Material specification for the work shall be as per clause 8.3.1.

8.4.2 Workmanship

All courses shall be laid truly horizontal and shall be of the same height in any course. The height of course shall not be less than 150 mm and not more than 300 mm. The width of stone shall not be less than its height.

Face stones shall tail into the work for not less than their height and at least 1/3rd the number of stones shall tail into the work for a length not less than twice their height but not more than three-fourths the thickness of the wall whichever is smaller. These should be laid as headers and stretchers alternately to break joints by at least 75 mm.

The face stones shall be squared on all joints and beds; the bed joints being hammer or chisel dressed true and square for at least 80 mm back from the face and the side joints for at least 40 mm. The face of the stone shall be hammer dressed so that the bushing shall not be more than 40 mm on an exposed face and 10 mm on a face to be plastered. No portion of the dressed surface shall show a depth of gap more than 6 mm from a straight edge placed on it. The remaining unexposed portion of the stone shall not project beyond the surface of bed and side joints.

No spalls or pinning's shall be allowed on the face. All bed joints shall be horizontal and side joints shall be vertical and no joints shall be more than 10 mm in thickness. When plastering or pointing is not required to be done, the joints shall be struck flush and finished as the work proceeds. Otherwise, the joints shall be raked to a minimum depth of 20 mm by a raking tool, during the progress of the work while the mortar is still green.

Hearting shall consist of flat bedded stones carefully laid on their proper beds and solidly bedded in mortar. The use of chips shall be restricted to the filling of interstices between the adjacent stones in hearting and these shall not exceed 10 percent of the quantity of the stone masonry. Care shall be taken so that no hollow spaces are left anywhere in the masonry.

The requirement regarding through or bond stones shall be as specified in clause 8.3.2 with the further stipulation that these shall be provided at 1.5 m to 1.8m apart clear in every course but staggered at alternate courses.

The quoins which shall be of the same height as the course in which they occur, shall not be less than 450 mm in any direction. Quoin stones shall be laid as stretchers and headers alternately. They shall be laid square on their beds, which shall be rough chisel dressed to a depth of at least 100 mm from the face. These stones shall have minimum uniform chisel drafts of 25mm width at four edges, all the edges being in the same plane.

Type of scaffolding to be used shall be as per Clause 8.2.2.

Requirements of execution of the work and curing shall be as stipulated in clause 8.3.2.

8.4.3 Measurement

Measurement shall be in cu. m correct to two places of decimal. The quantities measured and paid for, shall be those as actually executed after making necessary deductions for openings, lintels etc.

8.5 Concrete Block Masonry

8.5.1 Materials

Masonry units of solid concrete blocks shall conform to the requirements of IS : 2185 (Part 1).

Masonry units of solid light-weight concrete blocks shall conform to the requirements of IS : 2185 (Part 2).

Masonry units of autoclaved cellular concrete blocks shall conform to the requirements of IS:2185 (Part 3).

The height of the concrete masonry units shall not exceed either its length or six times its width.

The nominal dimensions of a concrete block shall be as follows.

Length 400, 500 or 600 mm

Height 100 or 200 mm

Width 100 to 300 mm in 50 mm increments

Half blocks shall be in lengths of 200, 250 or 300mm to correspond to the full length blocks. Actual dimensions shall be 10mm short of the nominal dimensions.

The maximum variation in the length of the units shall not be more than ±5 mm and maximum variation in height or width of the units shall not be more than ± 3mm.

Concrete blocks shall be of solid blocks and shall be sound, free of cracks, chipping or other defects which impair the strength or performance of the construction. Surface texture shall be as specified. The faces of the units shall be flat and rectangular, opposite faces shall be parallel and all arises shall be square. The bedding surfaces shall be at right angles to the faces of the block.

The concrete mix for the solid concrete blocks/light weight concrete blocks shall not be richer than one part of cement to six parts of combined aggregates by volume.

Concrete blocks shall be of approved manufacture, which satisfy the limitations in the values of water absorption, drying shrinkage and moisture movement, as specified for the type of block as per relevant IS code. Contractor shall furnish the test certificates and also supply the samples for the approval of Engineer.

8.5.2 Workmanship

The type of the concrete block, thickness, and grade based on the compressive strength for use in load-bearing and/or non-load-bearing walls shall be as specified. The minimum nominal thickness of non-load-bearing internal walls shall be 100mm. The minimum nominal thickness of external panel walls in framed construction shall be 200 mm.

The workmanship shall generally conform to the requirements of IS: 2572 for concrete block masonry, IS:6042 for light weight concrete block masonry and IS:6041 for autoclaved cellular concrete block masonry works.

From considerations of durability, generally concrete block masonry shall be used in superstructure works above the damp-proof course level.

Concrete blocks shall be embedded with a mortar which is relatively weaker than the mix of the blocks in order to avoid the formation of cracks. Cement mortar of proportion 1:6 shall be used for the works. Preparation of mortar shall be as specified in clause 8.2.1.

The thickness of both horizontal and vertical joints shall be 10mm. The first course shall be laid with greater care, ensuring that it is properly aligned, leveled and plumb since this will facilitate in laying succeeding courses to obtain a straight and truly vertical wall. For the horizontal (bedding) joint, mortar shall be spread over the entire top surface of the block including front and rear shells as well as the webs to a uniform layer of 10mm. For vertical joints, the mortar shall be applied on the vertical edges of the front and rear shells of the blocks. The mortar may be applied either to the unit already placed on the wall or on the edges of the succeeding unit when it is standing vertically and then placing it horizontally, well pressed against the previously laid unit to produce a compacted vertical joint. In case of two cell blocks with slight depression on the vertical sides these shall also be filled up with mortar to secure greater lateral rigidity. To assure satisfactory bond, mortar shall not be spread too far ahead of actual laying of the block as the mortar will stiffen and lose its plasticity Mortar while hardening shrinks slightly and thus pulls away from the edges of the block. The mortar shall be pressed against the units with a jointing tool after it has stiffened to effect intimate contact between the mortar and the unit to obtain a weather tight joint. The mortar shall be raked to a depth of 10mm as each course is laid to ensure good bond for the plaster.

As per the design requirements and to effectively control cracks in the masonry, RCC bound beams/studs, joint reinforcement shall be provided at suitable locations. Joint reinforcement shall be fabricated either from mild steel wires conforming to IS:280 or welded wire fabric/high strength deformed basis as per the drawings.

At the intersection of walls, the courses shall be laid up at the same time with a true masonry bond between at least 50% of the concrete blocks. The sequence for the construction of partition walls and treatment at the top of load-bearing walls for the RCC slab shall be as detailed under clause 8.2 for the brick work.

Curing of the mortar joints shall be carried out for atleast 7 days. The walls should only be lightly moistened and shall not be allowed to become excessively wet.

Double scaffolding as per clause 8.2.2 shall be adopted for execution of block masonry work.

Cutting of the units shall be restricted to a minimum. All horizontal and vertical dimensions shall be in respectively, adopting modular co-ordination for walls, opening locations for doors, windows etc.

Concrete blocks shall be stored at site suitably to avoid any contact with moisture from the ground and covered to protect against wetting.

8.5.3 Measurement

Measurement shall be in cu. m. correct up to two places of decimal for walls of thickness 200 mm and above. Measurement shall be in sq.m correct upto two places of decimal for walls of 100 mm/150 mm in thickness. Measurement shall be for the quantities as actually executed duly

deducting for openings and concrete works. Concrete and reinforcement will be measured and paid for separately. The rate quoted shall be for the type of masonry blocks specified in the respective items of work which shall include for the specific sequential operations as stipulated in the construction drawings.

8.6 Damp - Proof Course

8.6.1 Materials and Workmanship

Where specified, all the walls in a building shall be provided with damp-proof course cover plinth to prevent water from rising up the wall. The damp-proof course shall run without a break throughout the length of the wall, even under the door or other openings. Damp-proof course shall consist of 50 mm thick cement concrete of 1:2:4 nominal mix with approved water-proofing compound admixture conforming to IS: 2645 in proportion as directed by the manufacturer. Concrete shall be with 10 mm down graded coarse aggregates.

The surface of brickwork/stone masonry work shall be leveled and prepared before laying the cement concrete. Side shuttering shall be properly fixed to ensure that slurry does not leak through and is also not disturbed during compaction. The upper and side surface shall be made rough to afford key to the masonry above and to the plaster.

Damp-proof course shall be cured properly for atleast seven days after which it shall be allowed to dry for taking up further work.

8.6.2 Measurement

Measurement of damp-proof course shall be in sq.m correct to two places of decimal as actually executed. No separate payment will be made for formwork.

8.7 Miscellaneous Inserts, Bolts etc.

All the miscellaneous inserts such as bolts, pipes, plate embedment etc., shall be accurately installed in the building works at the correct location and levels, all as detailed in the construction drawings. Contractor shall prepare and use templates for this purpose, if so directed by the Engineer. In the event, of any of the inserts are improperly installed, Contractor shall make necessary arrangements to remove and reinstall at the correct locations/levels, all as directed by the Engineer without any extra cost to the Employer.

8.7 .1 Measurement

Miscellaneous inserts, supplied by the Contractor shall be measured and paid for as per the respective items of work.

8.8 Woodwork in Doors, Windows, Ventilators & Partitions

8.8.1 Materials

Timber to be used shall be first class Teak wood as per IS:4021. Timber shall be of the best quality and well seasoned by a suitable process before being planed to the required sizes. The maximum permissible moisture content shall be from 10 to 16 percent for timber 50mm and above in thickness and 8 to 14 percent of timber less than 50mm in thickness for different regions of the country as stipulated in IS:287. Timber shall be close grained, of uniform colour and free

from decay, fungal growth, boxed heart, pitch pockets or streaks on the exposed edges, borer holes, splits and cracks.

Flush door shutters of the solid core type with plywood face panels shall conform to IS: 2202 (Part 1), and those with particle board or hardboard face panels shall conform to IS: 2202 (Part 2).

Transparent sheet glass shall conform to the requirements of IS: 2835. Wired and figured glass shall be as per IS: 5437.

Builder's hardware for fittings and fixtures shall be of the best quality from approved manufacturers.

8.8.2 Workmanship

The workmanship and finish of wood work in doors, windows, ventilators and partitions shall be of a very high order. Contractor shall ensure that work is executed professionally by skilled carpenters for good appearance, efficient and smooth operation of the shutters.

All works shall be executed as per the detailed drawings and/or as directed by the Engineer.

All members of the door, window, and ventilator shall be straight without any warp or bow and shall have smooth well planed faces. The right angle shall be checked from the inside surfaces of the respective members of the frame. Frames shall have mortice and tenon joints which shall be treated with an approved adhesive and provided with metal or wood pins. The vertical members of the door frame shall project 50 mm below the finished floor level. The finished dimension of frames shall be rebated on the solid for keying with the plaster and for receiving the shutters. The depth of rebate for housing the shutter shall be 15 mm. The size of the frames shall be as specified in the respective items of work. The workmanship shall generally conform to the requirements specified in IS:4021.

The face of the frames abutting the masonry or concrete shall be provided with a coat of coal tar.

Three hold fasts using 25 mm x 6 mm mild steel flats 225 mm long with split ends shall be fixed on each side of door and window frames, one at the centre and the other two at 300 mm from the top and bottom of the frame. For window and ventilator frames less than 1 m in height, two hold fasts on each side shall be fixed at quarter points.

Timber panelled shutters for doors, windows and ventilators shall be constructed in the form of framework of stiles and rails with panel insertion. The panels shall be fixed by either providing grooves in the stiles and rails or by beading. Glazing bars shall be as detailed in the drawings. The stiles and rails shall be joined by mortice and tenon joints at right angles. All members of the shutter shall be straight without any warp or bow and shall have smooth, well planed faces at right angles to each other. The right angle for the shutter shall be checked by measuring the diagonals and the difference shall not be more than ± 3 mm. Timber panels made from more than one piece shall be jointed with a continuous tongued and grooved joint, glued together and reinforced with metal dowels. The workmanship shall generally conform to the requirements specified in IS: 1003 (Parts 1 & 2). The thickness of the shutter, width/thickness of the stiles/rails/panel type shall be as specified. Marine plywood panels conforming to IS: 710 shall be used for doors where specified.

Details of the wooden flush door shutters, solid core type with specific requirement of the thickness, core, face panels, viewing glazed panel, venetian louvre opening, teak wood lipping etc. shall be as specified. Panels of shutter shall be of marine plywood conforming to IS: 710. Flush door shutters shall be from reputed manufacturers and Contractor shall submit test results as per IS: 4020, if so desired by the Engineer.

Glazing of door, window, ventilator and partitions shall be with either flat transparent sheet glass, wired or figured glass. Transparent sheet glass shall be of 'B' quality as per IS: 2835.The thickness and type of glazing to be provided shall be as specified in the item of work.

The material of the fittings and fixtures either of chromium plated steel, cast brass, copper oxidised or anodised aluminium shall be as specified. The number, size and type of the fittings and fixtures shall be as indicated in the drawings/item of work.

Wood work shall not be provided with the finishes of painting/varnishing etc. unless it has been approved by the Engineer. The type of finish and the number of coats shall be as stipulated in the respective items of work.

Wooden hand railing and architraves shall be of the size and shape with the fixing arrangement as indicated in the drawings.

The framework of the partitions with mullions and transomes shall be with the sections of dimensions as specified. Panels of double/single glazing/plywood shall be fixed as per details specified. Partitions shall be fixed rigidly between the floor and structural columns/beams including provision of necessary shims for wedging etc. Finished work shall be of rigid construction, erected truly plumb to the lines and levels, at locations as per the Construction drawings.

Any carpentry work which shows defects due to inadequate seasoning of the timber or bad workmanship shall be removed and replaced by Contractor with work as per Specifications at no extra cost to the Employer.

8.8.3 Measurement

Measurement for doors, windows, ventilators, architraves and partitions shall be in sq.m correct to two places of decimal. Handrailing shall be measured in running metres correct to two places of decimal. Measurement shall be from out to out of the frames. Rates quoted shall be for all the works including glazing, painting, Builder’s hardware of fittings and fixtures as specifically described in the respective items of work.

8.9 Steel Doors, Windows and Ventilators

8.9.1 Materials

Hot rolled steel sections for the fabrication of steel doors, windows and ventilators shall conform to IS: 7452 which are suitable for single glazing.

Pressed steel door frames for steel flush doors shall be out of 1.25mm thick mild steel sheets of profiles as per IS : 4351.

Transparent sheet glass shall conform to the requirements of IS : 2835. Wired and figured glass shall be as per IS: 5437.

Builder's hardware of fittings and fixtures shall be of the best quality from the approved manufacturers.

8.9.2 Workmanship

All steel doors, windows and ventilators shall be of the type as specified in the respective items of work and of sizes as indicated in the drawings. Steel doors, windows and ventilators shall conform to the requirements as stipulated in IS : 1038. Steel windows shall conform to IS : 1361, if so specified.

Doors, windows and ventilators shall be of an approved manufacture. Fabrication of the unit shall be with rolled section, cut to correct lengths and mitred. Corners shall be welded to form a solid fused welded joint conforming to the requirements of IS : 1038. Tolerance in overall dimensions shall be within ±1.5mm. The frames and shutters shall be free from wrap or buckle and shall be square and truly plain. All welds shall be dressed flush on exposed and contact surfaces. Punching of holes, slots and other provisions to install fittings and fixtures later shall be made at the correct locations as per the requirements. Samples of the units shall be got approved by the Engineer before further manufacture/purchase by the Contractor.

Type and details of shutters, hinges, glazing bar requirement, couplings, locking arrangement, fittings and fixtures shall be as described in the respective items of work and / or as shown in the drawings for single or composite units.

For windows with fly proof mesh as per the item of work, rotor operator arrangement, for the operation of the glazed shutters from the inside shall be provided.

Pressed steel door frames shall be provided with fixing lugs at each jamb, hinges, lock-strike plate, mortar guards, angle threshold, shock-absorbers of rubber or similar material as per the requirements of IS : 4351. Pressed steel door frames shall be fixed as `built-in' as the masonry work proceeds. After placing it plumb at the specified location, masonry walls shall be built up solid on either side and each course grouted with mortar to ensure solid contact with the door frame, without leaving any voids. Temporary struts across the width shall be fixed, during erection to prevent bow/sag of the frame.

Door shutters of flush welded construction shall be 45mm thick, fabricated with two outer skins of 1.25mm thick steel sheets, 1mm thick steel sheet stiffeners and steel channels on all four edges. Double shutters shall have meeting stile edge bevelled or rebated. Provision of glazed viewing panel, louvers shall be made as per the items of works and/or drawings. Shutters shall be suitably reinforced for lock and other surface hardware and to prevent sagging/twisting. Single sheet steel door shutters shall be fabricated out of 1.25mm thick steel sheets, mild steel angles and stiffeners as per the drawings.

Doors, windows and ventilators shall be fixed into the prepared openings. They shall not be 'built-in' as the masonry work proceeds, to avoid distortion and damage of the units. The dimensions of the masonry opening shall have 10mm clearance all-round the overall dimensions of the frame for this purpose. Any support of scaffolding members on the frames/glazing bars is prohibited.

Glazing of the units shall be either with flat transparent glass or wired / figured glass of the thickness as specified in the items of works. All glass panels shall have properly squared corner and straight edges. Glazing shall be provided on the outside of the frames.

Fixing of the glazing shall be either with spring glazing clips and putty conforming to IS:419 or with metal beads. Pre-formed PVC or rubber gaskets shall be provided for fixing the beads with the concealed screws. The type of fixing the glazing shall be as indicated in the items of work and/or in drawings.

Steel doors, windows and ventilators shall be provided with finish of either painting as specified or shall be hot dip galvanised with thickness of the zinc coating as stipulated all as described in the respective items of works.

The material of the Builders hardware of fittings and fixtures of chromium plated steel, cast brass, brass copper oxidised or anodised aluminium shall be as specified in the items of works. The number, size and type of fittings and fixtures shall be as in the Drawings /items of work.

Installation of the units with fixing lugs, screws, mastic caulking compound at the specified locations shall generally conform to the requirements of IS:1081. Necessary holes etc required for fixing shall be made by the Contractor and made good after installation. Workmanship expected is of a high order for efficient and smooth operation of the units.

8.9.3 Measurement

Measurement shall be in sq.m correct to two places of decimal. Measurement shall be from out to out of the frames. Rates quoted shall be for the works including glazing, painting, Builder's hardware of fittings and fixtures as specifically described in the respective items of work.

8.10 Aluminium Doors, Windows, Ventilators & Partitions

8.10.1 Materials

Aluminium alloy used in the manufacture of extruded sections for the fabrication of doors, windows, ventilators shall conform to designation HE9-WP of IS:733.

Transparent sheet glass shall conform to the requirements of IS:2835. Wired and figured glass shall be as per IS:5437.

Builder's hardware of fittings & fixtures shall be of the best quality from approved manufacturers.

8.10.2 Workmanship

All aluminum doors, windows, ventilators and partitions shall be of the type and size as specified. The doors, windows, ventilators shall conform to the requirements of IS:1948. Aluminum windows, shall conform to IS:1949, if so specified.

All aluminum units shall be supplied with anodized finish. The minimum anodic film thickness shall be 0.015 mm.

Doors, windows and ventilators shall be of an approved manufacturer. Fabrication of the units shall be with the extruded sections, cut to correct lengths, mitred and welded at the corners to a true right angle conforming to the requirements of IS:1948. Tolerance in overall dimensions shall be within ± 1.5mm. The frames and shutters shall be free from warp or buckle and shall be square and truly plane. Punching of holes, slots and other provisions to install fittings or fixtures later shall be made at the correct locations, as per the requirements.

Aluminium swing type doors, aluminum sliding windows, partitions shall be as described in the items of work / drawings.

IS:1948 and IS:1949 refers to incorporating the sizes, shapes, thicknesses and weight per running metre of extruded sections for various components of the units. However, new sizes, shapes, thicknesses with modifications to suit snap-fit glazing clips etc. are continuously being added by various leading manufacturers of extruded sections, which are available in the market. As such, the sections of the various components of the unit proposed by the Contractor will be reviewed by the Engineer and will be accepted only if they are equal to or marginally more than that given in the codes / specified in the items of work.

The framework of the partitions with mullions and transoms shall be made of anodized aluminum box sections. Anodised aluminium box sections shall be in-filled with timber of class 3 (silver oak or any other equivalent) as per IS:4021. Panels of double/single glazing/plywood shall be fixed as per details indicated in the drawings. Partitions shall be fixed rigidly between the floor and the structural columns/beams including provision of necessary shims for wedging etc. Finished work shall be of rigid construction, erected truly plumb to the lines and levels, at locations as per the construction drawings.

Specific provisions as stipulated for steel doors, windows, ventilators under clause 8.9.2 shall also be applicable for this item work. Glazing beads shall be of the snap-fit type suitable for the thickness of glazing proposed as indicated in the items of works. A layer of clear transparent lacquer shall be applied on aluminium sections to protect them from damage during installation. This lacquer coating shall be removed after the installation is completed.

8.10.3 Measurement

Measurement shall be in sq.m correct to two places of decimal. Measurement shall be from out of the frames. Rate quoted shall be for the works including glazing, Builder's hardware of fittings and fixtures as specifically described in the respective items of work.

8.11 Steel Rolling Shutters

8.11.1 Materials and Workmanship

Rolling shutters shall be of an approved manufacture, conforming to the requirements specified in IS: 6248.

The type of rolling shutter shall be self coiling type (manual) for clear areas upto 12 sq.m, gear operated type (mechanical) for clear areas upto 35 sq.m and electrically operated type for areas upto 50 sq.m. Mechanical type of rolling shutters shall be suitable for operation from both inside and outside with the crank handle or chain gear operating mechanism duly considering the size of wall/column. Electrical type of rolling shutter shall also be provided with a facility for emergency mechanical operation.

Rolling shutters shall be supplied duly considering the type, specified clear width/height of the opening and the location of fixing as indicated in the drawings.

Shutters shall be built up of interlocking laths 75 mm width between rolling centres formed from cold rolled steel strips. The thickness of the steel strip shall not be less than 0.90 mm for shutters

upto 3.50m width and not less than 1.20 mm for shutters above 3.50 m width. Each lath section shall be continuous single piece without any welded joint.

The guide channels out of mild steel sheets of thickness not less than 3.15 mm shall be of either rolled, pressed or built up construction. The channel shall be of size as stipulated in IS:6248 for various clear widths of the shutters.

Hood covers shall be of mild steel sheets not less than 0.90 mm thick and of approved shape.

Rolling shutters shall be provided with a central hasp and staple safety device in addition to one pair of lever locks and sliding locks at the ends.

All component parts of the steel rolling shutter (excepting springs and insides of guide channels) shall be provided with one coat of zinc chrome primer conformity to IS:2074 at the shop before supply. These surfaces shall be given an additional coat of primer after erection at the site along with the number of coats and type of finish paint as specified in the respective items of work.

In case of galvanized rolling shutter, the lath sections, guides, lock plate, bracket plates, suspension shaft and the hood cover shall be hot dip galvanised with a zinc coating containing not less than 97.5 percent pure zinc. The weight of the zinc coating per sq.m shall be as specified in the items of work.

Guide channels shall be installed truly plumb at the specified location. Bracket plate shall be rigidly fixed with necessary bolts and holdfasts. Workmanship of erection shall ensure strength and rigidity of rolling shutter for trouble free and smooth operation.

8.11.2 Measurement

Measurement shall be in sq.m correct to two places of decimal of the clear area of the opening. Quoted rate shall be inclusive of painting as specified in the item of work.

8.12 Rubble Sub-Base

8.12.1 Materials

Stones used for rubble packing under floors on grade, foundations etc., shall be clean, hard, durable rock free from veins, flaws, laminations, weathering and other defects. Stones shall generally conform to the requirements stipulated in IS: 1597 (Part I).

Stones shall be as regular as can be obtained from quarries. Stones shall be of height equal to the thickness of the packing proposed with a tolerance of $\pm$ 10 mm. Stones shall not have a base area neither less than 250 sq cm nor more than 500 sq.cm, and the smallest dimension of any stone shall not be less than half the largest dimension. The quality and size of stones shall be subject to the approval of the Engineer.

8.12.2 Workmanship

Stones shall be hand-packed carefully and laid with their largest base downwards, resting flat on the prepared sub-grade and with their height equal to the thickness of the packing. Stones shall be laid breaking joints and in close contact with each other. All interstices between the stones shall be wedged-in by small stones of suitable size, well driven in by crow bars and hammers to ensure tight packing and complete filling-in of the interstices. The wedging shall be carried out

simultaneously with the placing in position of rubble packing and shall not lag behind. After this, any interstices between the smaller wedged stones shall be infilled with clean hard sand by brooming so as to fill the joints completely.

The laid rubble packing shall be sprinkled with water and compacted by using suitable rammers.

8.12.3 Measurement

Measurement shall be in sq.m correct to two places of decimal for the specified compacted thickness of rubble sub-base.

8.13 Base Concrete

The thickness and grade of concrete and reinforcement shall be as specified in items of work.

Before placing the blinding concrete, the sub-base of rubble packing shall be properly wetted and rammed. Concrete for the base shall then be deposited between the forms, thoroughly tamped and the surface finished level with the top edges of the forms. Two or three hours after the concrete has been laid in position, the surface shall be roughened using steel wire brush to remove any scum or laitance and swept clean so that the coarse aggregates are exposed. The surface of the base concrete shall be left rough to provide adequate bond for the floor finish to be provided later.

8.13.1 Measurement

Measurement shall be in sq.m correct to two places of decimal. This work could be either separate or combined along with the floor finish as indicated in the respective items of work.

8.14 Terrazzo and Plain Cement Tiling Work

8.14.1 Materials

Terrazzo tiles and cement tiles shall generally conform in all respects to standards stipulated in IS: 1237. Tiles shall be of the best quality manufactured adopting hydraulic pressure of not less than $14N/mm^2$.

The type, quality, size, thickness colour etc, of the tiles for flooring/dado/skirting shall be as specified in the items of work.

The aggregates for terrazzo topping shall consist of marble chips that are hard, sound, and dense. Cement to be used shall be either ordinary Portland cement or white cement with or without colouring pigment. The binder mix shall be 3 parts of cement to 1 part of marble powder by weight. The proportion of cement shall include any pigments. For every one part of cement-marble powder binder mix, the proportion of aggregates shall be 1.75 parts by volume, if the chips are between 1mm to 6mm and 1.50 parts by volume if the chips are between 6mm to 25mm.

The minimum thickness of the wearing layer of terrazzo tiles shall be 5mm for tiles with chips of size varying from 1mm up to 6mm or from 1mm up to 12mm. This shall be 6mm for tiles with chips varying from 1mm upto 25mm. The minimum thickness of wearing layer of cement/coloured cement tiles shall be 5mm. This shall be 6mm for heavy-duty tiles. The pigment used in the wearing layer shall not exceed 10 percent of the total weight of cement used in the mix.

8.14.2 Workmanship

Laying and finishing of tiles shall conform to the requirements of workmanship stipulated in IS:1443.

Tiling work shall be commenced only after the door and window frames are fixed and plastering of the walls/ ceiling is completed. Wall plastering shall not be carried out upto about 50mm above the level of proposed skirting/dado.

The base concrete shall be finished to a reasonably plane surface about 40 to 45mm below the level of finished floor. Before the tiling work is taken up, the base concrete or structural slab shall be cleaned of all loose materials, mortar droppings, dirt, laitance etc. using steel wire brush and well wetted without allowing any water pools on the surface.

A layer of 25mm average thickness of cement mortar consisting of one part of cement to 6 parts of sand shall be provided as bedding for the tiles over the base concrete. The thickness of bedding mortar shall not be less than 10mm at any place. The quantity of water to be added for the mortar shall be just adequate to obtain the workability for laying. Sand for the mortar shall conform to IS:2116 and shall have minimum fineness modulus of 1.5. The surface shall be left rough to provide a good bond for the tiles. The bedding shall be allowed to harden for a day before laying of the tiles.

Neat cement slurry using 4.4 kg of cement per sq.m of floor area shall be spread over the hardened mortar bedding over such an area at a time as would accommodate about 20 tiles. Tiles shall be fixed in this slurry one after the other, each tile being gently tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. The joints shall be in straight lines and shall normally be 1.5mm wide. On completion of laying of the tiles in a room, all the joints shall be cleaned and washed fairly deep with a stiff broom/wire brush to a minimum depth of 5mm. The day after the tiles have been laid, the joints shall be filled with cement grout of the same shade as the colour of the tile matrix. For this purpose, white cement or grey cement with or without pigments shall be used. The flooring should be kept moist and left undisturbed for 7 days to allow the bedding and joints to set properly. Heavy traffic shall not be allowed on the floor for atleast 14 days after fixing of the tiles.

About a week after laying the tiles, each tile shall be lightly tapped with a small wooden mallet to determine if it produces a hollow sound. If it does, the affected tiles, along with any other cracked or broken tiles, shall be removed and replaced with new tiles to ensure proper line and level. The same procedure shall be followed again after grinding the tiles, and all damaged tiles shall be replaced, properly jointed, and finished to match. To ensure that the replaced tiles match those laid earlier, it is necessary for the Contractor to procure a sufficient quantity of extra tiles to meet this contingency.

Wherever a full tile cannot be provided, tiles shall be cut to size and fixed. Floor tiles adjoining the wall shall go about 10mm under the plaster, skirting or dado.

Tile skirting and dado work shall be executed only after laying tiles on the floor. For dado and skirting work, the vertical wall surface shall be thoroughly cleaned and wetted. Thereafter, it shall be evenly and uniformly covered with a 10mm thick backing of 1:4 cement-sand mortar. For this work the tiles as obtained from the factory shall be of the size required and practically full polished. The back of each tile to be fixed shall be covered with a thin layer of neat cement paste

and the tile shall then be gently tapped against the wall with a wooden mallet. Fixing shall be done from the bottom of the wall upwards. The joints shall be in straight lines and shall normally be 1.5mm wide. Any difference in the thickness of the tiles shall be evened out in the backing mortar or cement paste so that the tile faces are in conformity & truly plumb. Tiles for use at the corners shall be suitably cut with bevelled edges to obtain a neat and true joint. After the work has set, hand polishing with carborundum stones shall be done so that the surface matches with the floor finish. Contractor shall note that the unit rate quoted for skirting shall also include for any chipping of the brickwork required to be carried out for this item.

Wall plastering of the strip left out above the level of skirting/dado shall be taken up after the tiles are fixed.

Chequered terrazzo tiles for flooring and for stair treads shall be delivered to site after the first machine grinding.

Machine grinding and polishing shall commence only after a 14-day lay period. The sequence and three numbers of machine grinding operations, usage of the type of carborundum stones, filling up of pin holes, watering etc. shall be carried out all as specified in IS:1443.

Tiles shall be laid to the levels specified. Where large areas are to be tiled the level of the central portion shall be kept 10mm higher than that at the walls to overcome optical illusion of a depression in the central portion. Localized deviation of ±3mm in any 3m length is acceptable in a nominally flat floor.

8.14.3 Measurement

Measurement for floor tiling and dado shall be in sq. m, correct to two decimal places. Actual quantity of tiling work as laid shall be measured for payment as per the respective items of work after making deductions for openings etc. Measurement for skirting shall be in running metres correct to two places of decimal for the specified height as per the item of work.

8.15 In-Situ Terrazzo Work

8.15.1 Materials

The requirements of marble aggregates for terrazzo topping shall be as per clause 8.14.1.

Cement shall first be mixed with the marble powder in dry state. The mix thus obtained shall be mixed with the aggregates in the specified proportions. Care shall be taken not to get the materials into a heap which results in the coarsest chips falling to the edges and cement working to the centre at the bottom. Materials shall be kept, as far as possible, in an even layer during mixing. After the materials have been thoroughly mixed in the dry state, water shall be added, just adequate to obtain plastic consistency for the desired workability for laying. The mix shall be used in the works within 30 minutes of the addition of water to the cement.

8.15.2 Workmanship

The thickness, type, quality, size and colour of chips etc. for the in-situ terrazzo finish for flooring/dado/ skirting shall be as specified in the respective items of works. Laying and finishing of in-situ work shall conform to the requirements of workmanship stipulated in IS: 2114.

In-situ terrazzo finish shall be laid over hardened concrete base. The finish layer consists of an under layer and terrazzo topping. The underlayer shall be of cement concrete of mix 1:2:4 using 10mm down graded coarse aggregates. The combined thickness of under layer and topping shall not be less than 30 mm for flooring and 20mm for dado/skirting work.

The minimum thickness of topping shall be 6mm if chips used are between 1mm to 4mm, 9mm if chips are between 4mm to 7mm and 12mm if chips are between 7mm to 10mm. If chips larger than 10mm size are used, the minimum thickness shall be one and one third the maximum size of chips.

Both the under layer and later the topping shall be divided into panels not exceeding 2 sq.m for laying so as to reduce the possibility of development of cracks. The longer dimension of any panel shall not exceed 2m. Dividing strips shall be used to separate the panels. When the dividing strips are not provided, the bays shall be laid alternately, allowing an interval of atleast 24 hours between laying adjacent bays.

Dividing strips shall be either of aluminium, brass or other material as indicated in the items of works. Aluminum strips should have a protective coating of bitumen. The thickness of the strips shall be not less than 1.5mm and width not less than 25mm for flooring work.

Concrete base shall be finished to a reasonably plane surface to a level below the finished floor elevation equal to the specified thickness of terrazzo finish. Before spreading the underlayer, the base concrete surface shall be cleaned of all loose materials, mortar droppings, dirt, laitance etc. and well wetted without allowing any water pools on the surface. Dividing strips or screed strips, if dividing strips are not provided shall be fixed on the base and levelled to the correct height to suit the thickness of the finish. Just before spreading the underlayer the surface shall be smeared with cement slurry at 2.75 Kg/sq.m. Over this slurry, the underlayer shall be spread and levelled with a screening board. The top surface shall be left rough to provide a good bond for the terrazzo topping.

Terrazzo topping shall be laid while the underlayer is still plastic and normally between 18 to 24 hours after the underlayer is laid. Cement slurry of the same colour as the topping shall be brushed on the surface immediately before laying is commenced. The terrazzo mix shall be laid to a uniform thickness and compacted thoroughly by tamping and with a minimum of troweling. Straight edge and steel floats shall be used to bring the surface true to the required level in such a manner that the maximum amount of marble chips come up and spread uniformly all over the surface.

The surface shall be left dry for air-curing for a period of 12 to 18 hours. Thereafter, it shall be cured by allowing water to stand in pools for a period of not less than 4 days.

Machine grinding and polishing shall be commenced only after a lapse of 7 days from the time of completion of laying. The sequence and four numbers of machine grinding operations, usage of the type of carborundum stones, filling up of pinholes, wet curing, watering etc shall be carried out all as specified in IS: 2114.

8.15.3 Measurement

Measurement shall be as per clause 8.14.3.

8.16 Shahabad / Tandur/ Kota Stone Slab/ Granite flooring work

8.16.1 Materials

The slabs shall be of approved selected quality, hard, sound, dense and homogenous in texture, free from cracks, decay, weathering and flaws. The percentage of water absorption shall not exceed 5 percent as per test conducted in accordance with IS : 1124.

The slabs shall be hand or machine cut to the required thickness. Tolerance in thickness for dimensions of tile more than 100mm shall be ±5mm. This shall be ±2mm on dimensions less than 100mm.

Slabs shall be supplied to the specified size with machine cut edges or fine chisel dressed to the full depth. All angles and edges of the slabs shall be true and square, free from any chipping giving a plane surface. Slabs shall have the top surface machine polished (first grinding) before being brought to site. The slabs shall be washed clean before laying.

8.16.2 Workmanship

The type, size, thickness and colour/shade etc. of the slabs for flooring/dado/skirting shall be as specified in the respective items of work.

Preparation of the concrete base, laying and curing shall be as per clause 8.14.2.

Dado / skirting work shall be as per clause 8.14.2. The thickness of the slabs for dado/skirting work shall not be more than 25mm. Slabs shall be so placed that the back surface is at a distance of 12mm. If necessary, slabs shall be held in position temporarily by suitable method. After checking for verticality, the gap shall be filled and packed with cement sand mortar of proportion 1:3. After the mortar has acquired sufficient strength, the temporary arrangement holding the slab shall be removed.

Grinding and polishing shall be as per clause 8.14.2 except that first grinding with coarse grade carborundum shall not be done and cement slurry with or without pigment shall not be applied before polishing.

8.16.3 Measurement

Measurement shall be as per clause 8.14.3.

8.17 Carborundum Tile Finish

8.17.1 Materials

Carborundum tiles shall generally conform in all respects to the standards stipulated in IS:1237 for heavy duty tiles. Tiles shall be of the best quality manufactured adopting hydraulic pressure of not less than 14 N/mm^2.

The topping shall be uniform and of thickness not less than 6mm. The quantity of carborundum grit shall be not less than 1.35 kg/sq.m used with cement with or without pigment. The carborundum grit shall pass through 1.18mm mesh and shall be retained on 0.60 mm mesh.

The size, thickness, colour and plain or chequered etc of the tiles for flooring / skirting shall be as specified in the respective items of work.

8.17.2 Workmanship

Requirements as detailed for terrazzo/cement tile finish under clause 8.14.2 shall be applicable for carborundum tile flooring.

8.17.3 Measurement

Measurement shall be as per clause 8.14.3.

8.18 Glazed Tile Finish

8.18.1 Materials

Glazed earthenware tiles shall conform to the requirements of IS: 777. Tiles shall be of the best quality from an approved manufacturer. The tiles shall be flat, true to shape and free from flaws such as crazing, blisters, pinholes, specks or welts. Edges and underside of the tiles shall be free from glaze and shall have ribs or indentations for a better anchorage with the bedding mortar. Dimensional tolerances shall be as specified in IS: 777.

8.18.2 Workmanship

The size, thickness, colour, with or without designs etc of the tiles for flooring/dado/skirting shall be as specified in the respective items of work.

The total thickness of glazed tile finish including the bedding mortar shall be 20 mm in flooring/dado/skirting. The minimum thickness of bedding mortar shall be 12mm for flooring and 10mm for dado/skirting work.

The bedding mortar shall consist of 1 part of cement to 3 parts of sand mixed with just sufficient water to obtain proper consistency for laying. Sand for the mortar shall conform to IS: 2116 and shall have minimum fineness modulus of 1.5.

Tiles shall be soaked in water for about 10 minutes just before laying. Where full size tiles cannot be fixed, tiles shall be cut to the required size using special cutting device and the edges rubbed smooth to ensure straight and true joints.

Colored tiles with or without designs shall be uniform and shall be preferably procured from the same batch of manufacture to avoid any differences in the shade.

Tiles for the flooring shall be laid over hardened concrete base. The surface of the concrete base shall be cleaned of all loose materials, mortar droppings etc well wetted without allowing any water pools on the surface. The bedding mortar shall then be laid evenly over the surface, tamped to the desired level and allowed to harden for a day. The top surface shall be left rough to provide a good bond for the tiles. For skirting and dado work, the backing mortar shall be roughened using a wire brush.

Neat cement slurry using 3.3 kg cement per sq.m of floor area shall be spread over the hardened mortar bed over such an area as would accommodate about 20 tiles. Tiles shall be fixed in this slurry one after the other, each tile being gently tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. For skirting and dado work, the back of the tiles shall be smeared with cement slurry for setting on the backing mortar. Fixing of tiles shall be done from the bottom of the wall upwards. The joints shall be in perfect straight lines and as thin as

possible but shall not be more than 1mm wide. The surface shall be checked frequently to ensure correct level/required slope. Floor tiles near the walls shall enter skirting/dado to a minimum depth of 10mm. Tiles shall not sound hollow when tapped.

All the joints shall be cleaned of grey cement with wire brush to a depth of atleast 3mm and all dust, loose mortar etc. shall be removed. White cement with or without pigment shall then be used for flush pointing the joints. Curing shall then be carried out for a minimum period of 7 days for the bedding and joints to set properly. The surface shall then be cleaned using a suitable detergent, fully washed and wiped dry.

Specials consisting of coves, internal and external angles, cornices, beads and their corner pieces shall be of thickness not less than the tiles with which they are used.

8.18.3 Measurement

Measurement shall be as per Clause 8.14.3.In-Situ Cement Concrete Floor Topping

8.18.4 Materials

The mix proportion for the in-situ concrete floor topping shall be 1:2.5:3.5 (one part cement: two and half parts sand: three and half parts coarse aggregates) by volume unless otherwise specified in the items of work.

The aggregates shall conform for the requirements of IS: 383.

Coarse aggregates shall have high hardness surface texture and shall consist of crushed rock of granite, basalt, trap or quartzite. The aggregate crushing valve shall not exceed 30 percent. The grading of the aggregates of size 12.5mm and below shall be as per IS: 2571.

Grading of the sand shall be within the limits indicated in IS: 2571.

8.18.5 Workmanship

The thickness of the floor topping shall be as specified in the items of work. The minimum thickness of the floor topping shall be 25mm.

Preparation of base concrete/structural slab before laying the topping shall be as per clause 8.13. The surface shall be rough to provide adequate bond for the topping.

Mixing of concrete shall be done thoroughly in a mechanical mixer unless hand mixing is specifically permitted by the Engineer. The concrete shall be as stiff as possible and the amount of water added shall be the minimum necessary to give just sufficient plasticity for laying and compacting. The mix shall be used in the work within 30 minutes of the addition of water for its preparation.

Floor finish shall be laid in suitable panels to reduce the risk of cracking. No dimension of a panel shall exceed 2 meters and the length of a panel shall not exceed one and a half times its breadth. Topping shall be laid in alternate panels, the intermediate panels being cast after a gap of atleast one day. Construction joints shall be plain vertical butt joints.

Screed strips shall be fixed dividing the area into suitable panels. Immediately before depositing the concrete topping, neat cement slurry at 2.75 kg/sq.m of area shall be thoroughly brushed into

the prepared surface. Topping shall then be laid, very thoroughly tamped, struck off level and floated with wooden float. The surface shall then be tested with a straight edge and mason's spirit level to detect any inequalities and these shall be made good immediately.

Finishing of the surface by troweling shall be spread over a period of one to six hours depending upon the temperature and atmospheric conditions. The surface shall be trowelled 3 times at intervals so as to produce a smooth uniform and hard surface. Immediately after laying, the first trowelling just sufficient to give a level surface shall be carried out avoiding excessive trowelling at this stage. The surface shall be re- trowelled after sometime to close any pores and to scrap off excess water or laitance, which shall not be trowelled back into the topping. Final trowelling shall be done well before the concrete has become too hard but at a time when considerable pressure is required to make any impression on the surface. Sprinkling of dry cement or cement-sand mixture for absorbing moisture shall not be permitted.

Immediately after the surface is finished, it shall be protected suitably from rapid drying due to wind/ sunlight. After the surface has hardened sufficiently to prevent any damage to it, the topping shall be kept continuously moist for a minimum period of 10 days.

It is preferable to lay the topping on hardened base concrete, as against being laid monolithically with a lesser thickness, since proper levels and slopes with close surface tolerances is achievable in practice, owing to its greater thickness. Further, as this would be laid after all other building operations are over, there will be no risk of any damages or discoloration to the floor finish which are difficult to repair satisfactorily.

8.18.6 Measurement

Measurement shall be in sq.m correct upto two places of decimal.

8.19 In-Situ Granolithic Concrete Floor Topping

8.19.1 Materials and Workmanship

The requirements of materials and workmanship shall be all as per clause 8.19 for in-situ cement concrete floor topping except that the mix proportion of the concrete shall be 1:1:2 (cement:sand:coarse aggregates) by volume.

The minimum thickness of granolithic floor topping on hardened concrete base shall be 40mm.

8.19.2 Measurement

Measurement shall be in sq.m correct upto two places of decimal.

8.20 Floor Hardener Topping

8.20.1 Materials & Workmanship

Floor hardener topping shall be provided either as integrally finished over the structural slab/grade slab or laid monolithically with the concrete/granolithic floor finish on top of hardened concrete base.

Floor hardener of the metallic or non-metallic type suitable for the performance of normal / medium/ heavy duty function of the floor, the quantum of ingredients and the thickness of topping shall be as specified in the respective items of work.

For monolithic application with the floor finish/slab the thickness of the layer shall be 15mm. The topping shall be laid within 2 to 3 hours after concrete is laid when it is still plastic but stiffened enough for the workmen to tread over it by placing planks. The surface of the concrete layer shall be kept rough for providing adequate bond for the topping. Laitance shall be removed before placing the topping. The topping shall be screened and thoroughly compacted to the finished level. Trowelling to a smooth finish shall be carried out as per clause 8.19.2. After the surface has hardened sufficiently, it shall be kept continuously moist for atleast 10 days.

The procedure for mixing the floor hardener topping shall be as per manufacturer's instructions.

Surface shall be prevented from any damages due to subsequent building operations by covering with 75 mm thick layer of sand.

8.20.2 Measurement

Measurement shall be in sq.m correct to two places of decimal. This could be either separate or combined along with the floor finish as indicated in the respective items of work.

8.21 PVC Sheet/Tile Flooring

8.21.1 Materials

PVC floor covering shall be of either unbacked homogeneous flexible type in the form of sheets/tiles conforming to IS: 3462 or homogeneous PVC asbestos tiles conforming to IS:3461.

The surface of the sheets/tiles shall be free from any physical defects such as pores, blisters, cracks etc. which affects the appearance and serviceability. Tiles/ sheets shall meet with the tolerance limits in dimensions specified in the IS. Contractor shall submit the test certificates, if so desired by the Engineer.

Each tile/sheet shall be legibly and indelibly marked with the name of the manufacturer or his trade mark, IS certificate mark, and batch number.

The adhesive to be used for laying the PVC flooring shall be rubber based and of the make as recommended and approved by the manufacturer of PVC sheets/tiles.

The type, size, colour, plain or mottled and the pattern shall be as specified in the respective items of work.

8.21.2 Workmanship

PVC floor covering shall be provided over an underbed of cement concrete floor finish over the base concrete or structural slab. The sub-floor and the underbed must be perfectly dry before laying the PVC flooring. This shall be ensured by methods of testing as stipulated in Appendix-A of IS: 5318.

The surface of the underbed shall have trowelled finish without any irregularities which creates poor adhesion. Surface shall be free of oil or grease and thoroughly cleaned of all dust, dirt and wiped with a dry cloth.

PVC sheets/tiles shall be brought to the temperature of the area in which they are to be laid by stacking in a suitable manner within or near the laying area for a period of about 24 hours. Where air-conditioning is installed, the flooring shall not be laid on the underbed until the A/C units have been in operation for atleast 7 days. During this period, the temperature range shall be between 20deg.C and 30deg.C and this shall be maintained during the laying operations and also for 48 hours thereafter.

Layout of the PVC flooring shall be marked with guidelines on the underbed and PVC tiles/sheets shall be first laid for trial, without using the adhesive, according to the layout.

The adhesive shall be applied by using a notched trowel to the surface of the underbed and to the backside of PVC sheets/tiles. When the adhesive has set sufficiently for laying, it will be tacky to the touch, which generally takes about 30 minutes. The time period need be carefully monitored since a longer interval will affect the adhesive properties. Adhesive shall be uniformly spread over only as much surface area at one time which can be covered with PVC flooring within the stipulated time.

PVC sheet shall be carefully taken and placed in position from one end onwards slowly so that the air will be completely squeezed out between the sheet and the background surface and no air pockets are formed. It shall then be pressed with a suitable roller to develop proper contact. The next sheet shall be laid edge to edge with the sheet already laid, so that there is minimum gap between joints. The alignment shall be checked after each row of sheet is completed and trimmed if considered necessary.

Tiles shall be laid in the same manner as sheets and preferably, commencing from the centre of the area. Tiles should be lowered in position and pressed firmly on to the adhesive with minimum gap between the joints. Tiles shall not be slided on the surface. Tiles shall be rolled with a light wooden roller of about 5kg to ensure full contact with the underlay. Work should be constantly checked to ensure that all four edges of adjacent tiles meet accurately.

Any excess adhesive which may squeeze up between sheets/tiles shall be wiped off immediately with a wet cloth. Suitable solvents shall be used to remove hardened adhesive.

A minimum period of 24 hours shall be given after laying for the development of proper bond of the adhesive. When the flooring is thus completed, it shall be cleaned with a wet cloth soaked in warm soap solution.

Metallic edge strips shall be used to protect the edges of PVC sheets/tiles which are exposed as in doorways/ stair treads.

Hot sealing of joints between adjacent PVC sheet flooring to prevent creeping of water through the joints shall be carried out, using special equipment as per manufacturer's instructions.

8.21.3 Measurement

Measurement shall be in sq.m correct to two places of decimal. The item could be either separate or as a combined item with the floor finish as specified in the respective items of work.

8.22 Acid Resisting Brick/Tiling Work

8.22.1 Materials

The ceramic unglazed vitreous acid resisting tiles shall conform to the requirements of IS: 4457. Acid resistant bricks shall conform to the requirements of IS: 4860.

The finished tile/brick when fractured shall appear fine grained in texture, dense and homogeneous. Tile/brick shall be sound, true to shape, flat, free from flaws and any manufacturing defects affecting their utility. Tolerance in dimensions shall be within the limits specified in the respective IS.

The tiles/bricks shall be bedded and jointed using chemical-resistant mortar of the resin type conforming to IS: 4832 (Part II). Method of usage shall generally be as per the requirements of IS: 4443.

8.22.2 Workmanship

The size and thickness of tiles/size and class of bricks for use in the flooring/skirting/dado shall be as specified in the respective items of work.

The resin shall have viscosity for readily mixing with the filler by manual methods. The filler shall have graded particles which permit joint thickness of 1.5 mm.

The base concrete surface shall be free from dirt and thoroughly dried. The surface shall be applied with a coat of bitumen primer conforming to IS:3384. The primed surface shall then be applied with a uniform coat of bitumen conforming to IS:1580. Tiles or bricks shall be laid directly without the application of bitumen, if epoxy or polyester resin is used for the mortar.

A sufficient quantity of mortar, as specified by the manufacturer, shall be prepared at one time for bedding and jointing purposes. Rigid PVC, stainless steel, and chromium-plated tools shall be used for mixing and laying.

For laying the floor 6 to 8 mm thick mortar shall be spread on the back of the tile/brick. Two adjacent sides of the tile/brick shall be smeared with 4 to 6 mm thick mortar. Tile/brick shall be pressed into the bed and pushed against the floor, and with the adjacent tile/brick, until the joint in each case is 2 to 3 mm thick. The excess mortar shall then be trimmed off and allowed to harden completely. Similar procedure shall be adopted for the work on walls by pressing the tile/brick against the prepared wall surfaces, and only one course shall be laid at a time until the initial setting period.

The mortar joints shall be cured for a minimum period of 72 hours with 20 to 25% hydrochloric acid or 30 to 40% sulphuric acid. After acid curing, the joints shall be washed with water and allowed to thoroughly dry. The joints shall then be filled with mortar to make them smooth and plane. Acid curing is not required to be carried out if epoxy or polyester resin is used for the mortar.

Resin mortars are normally self curing. The area tiled shall not be put to use before 48 hours in case epoxy, polyester and furane type of resin is used for the mortar. If phenolic or cashewnut shell liquid resin is used for the mortar, the area tiled shall not be put to use for 7 to 28 days respectively, without heat treatment. This period shall be 2 to 6 days respectively, if heat treatment is given with infrared lamp.

8.22.3 Measurement

Measurement shall be in sq.m correct to two places of decimal for flooring/dado. Measurement shall be in running metres correct to two places of decimal for skirting of height as specified in the item of work.

8.23 Heavy Duty Abrasion Resistant Flooring

The type, quality, size, thickness, colour, etc., of the tile for flooring and skirting work shall be of the best quality approved by the Engineer. For this purpose, the Contractor shall provide the Engineer with necessary samples for this selection. Tiles shall be hardwearing, resistant to impact, resistant to abrasion, free from slipperiness and also resistant to attack by water, oils and greases.

8.24 Epoxy Lining Work

8.24.1 Materials

The epoxy resin and hardener formulation for laying of jointless lining work in floors and walls of concrete tanks/trenches etc shall be as per the requirements of IS: 9197.

The epoxy composition shall have the chemical resistance to withstand the following conditions of exposure:

a) Hydrochloric acid upto 30% concentration

b) Sodium hydroxide upto 50% concentration

c) Liquid temperature upto 60deg.C

d) Ultraviolet radiation

e) Alternate wetting and drying

Sand shall conform to grading zone III or IV of IS: 383.

The hardener shall be of the liquid type such as Aliphatic Amine or an Aliphatic/Aromatic Amine Adduct for the epoxy resin. The hardener shall react with epoxy resin at normal ambient temperature.

Contractor shall furnish test certificates for satisfying the requirements of the epoxy formulation if so directed by the Engineer.

8.24.2 Workmanship

The minimum thickness of epoxy lining shall be 4 mm. It is essential that the concrete elements are adequately designed to ensure that water is excluded to permeate to the surface, over which the epoxy lining is proposed.

The epoxy lining shall be of the trowel type to facilitate execution of the required thickness for satisfactory performance.

The concrete surfaces over which epoxy lining is to be provided shall be thoroughly cleaned of oil or grease by suitable solvents, wire brushed to remove any dirt/dust and laitance. The surfaces

shall then be washed with dilute hydrochloric acid and rinsed thoroughly with plenty of water or dilute ammonia solution. The surfaces shall then be allowed to dry. It is essential to ensure that the surfaces are perfectly dry before the commencement of epoxy application.

Just adequate quantity of epoxy resin which can be applied within the pot life as specified by the manufacturer shall be prepared at one time for laying and jointing.

Rigid PVC/stainless steel/chromium plated tools shall be used for laying. Trowelling shall be carried out to obtain uniformly the specified thickness of lining.

Lining shall be allowed to set without disturbance for a minimum period of 24 hours. The facility shall be put to use only after a minimum period of 7 days of laying of the lining.

8.24.3 Measurement

Measurement shall be in sq.m correct to two places of decimal.

8.25 Water-Proofing

Machine-made flat Yelahanka tiles shall be of the size and thickness as specified in the item of work. Tiles shall be soaked in water for atleast one hour before laying. The tiles shall be laid on a mortar bed of cement mortar 1:3 with an average thickness of 25mm. Tiles shall be laid, open jointed with 4 to 6 mm wide joints, flat on the mortar and lightly pressed and to set to a plane surface true to slope, using a trowel and a wooden straight edge. They shall be laid with their longitudinal lines of joints truly parallel and generally at right angles to the direction of the run-off gradient. Transverse joints in alternate rows shall come directly in line with each other. Transverse joints in adjacent courses shall break joints by atleast 50 mm. The joints shall be filled and flush-pointed with a 1:3 cement mortar mixed with red oxide. Curing shall be carried out for a minimum period of seven days.

8.25.1 General

The work shall include waterproofing for the building roofs, terraces, toilets, floor slabs, walls, planters, chajjas, sills and any other areas and at any other locations and situations as directed by the Engineer.

The waterproofing treatment shall be carried out on top of lime concrete (brick bat coba) laid to slope on roof surfaces. The brick bat coba shall be covered as specified below.

The work shall be carried out by an experienced specialist Sub-Contractor who shall be appointed only after prior approval of the Engineer.

8.25.2 Modified Bituminous Membrane

Modified Bituminous Membrane shall be “SUPER THERMOLAY” 4 mm thick weighing 4 Kg/sqm, manufactured using APP Polymer modified bitumen with a central core of non-woven polyester reinforcement (200 gms/sqm) and with top and bottom layers of thermofusible film (top layer could also be sand finished) made by STP Limited in collaboration with Bitumat Company Limited. “PLYFLEX” of Bitumat Company Limited, Saudi Arabia supplied by STP Limited shall also be acceptable or other equivalent specification.

8.25.3 Waterproofing of Roofs with Lime Concrete

(a) Materials

Broken brick coarse aggregates prepared from well/over burnt bricks shall be well graded having a maximum size of 25mm and shall generally conform to IS:3068.

Lime shall be class C lime (fat lime) or factory-made hydrated lime conforming to IS:712.

(b) Workmanship

Lime concrete shall be prepared by thoroughly mixing the brick aggregates inclusive of brick dust obtained during breaking with the slaked lime in the proportions of 2 1/2 (two and a half) parts of brick aggregates to 1 part of slaked lime by volume. Water shall be added just adequate to obtain the desired workability for laying. Washing soap and alum shall be dissolved in the water to be used. The quantity of these materials required per cum of lime concrete shall be 12kg of washing soap and 4kg of alum. Brick aggregates shall be soaked thoroughly in water for a period of not less than six hours before use in the concrete mix. Lime concrete shall be used in the works within 24 hours after mixing.

The roof surface over which the water-proof treatment is to be carried out shall be cleaned of all foreign matter by wire brushing, dusting and made thoroughly dry. Preparation of surfaces shall be as stipulated in IS: 3067.

The slope of the finished waterproofing treatment shall be not less than 1 in 60 for efficient drainage. This shall be achieved either wholly in the lime concrete layer or otherwise as indicated in the drawings.

The average thickness of lime concrete, slope, and the finish on top of machine-made burnt clay flat terracing tiles conforming to IS:2690 (part I) shall be as specified in the items of work. Cement concrete flooring tiles in lieu of clay terracing tiles shall be provided if so specified in the items of work, duly considering the traffic the terrace will be subjected to.

The minimum compacted thickness of lime concrete layer shall be 75mm and average thickness shall not be less than 100mm. In case, the thickness is more than 100mm, it shall be laid in layers not exceeding 100mm to 125mm.

Laying of lime concrete shall be commenced from a corner of the roof and proceeded diagonally towards centre and other sides duly considering the slopes specified for effectively draining the rain-water towards the downtake points.

Lime concrete fillet for a minimum height of 150mm shall be provided all along the junction of the roof surface with the brick masonry wall/parapet/column projections. These shall then be finished on top with provision of clay terracing tiles/cement concrete tiles.

After the lime concrete is laid it shall be initially rammed with a rammer weighing not more than 2 Kg and the finish brought to the required evenness and slope. Alternatively, bamboo strips may be used for the initial ramming. Further consolidation shall be done using wooden THAPIES with rounded edges. The beating will normally have to be carried on for at least seven days until the THAPI makes no impression on the surface and rebounds readily from it when struck. Special care shall be taken to properly compact the lime concrete at its junction with parapet walls or column projections.

During compaction by hand-beating, the surface shall be sprinkled liberally with lime water (1 part of lime putty and 3 to 4 parts of water) and a small proportion of sugar solution for obtaining improved water-proofing quality of the lime concrete. On completion of beating, the mortar that comes on the top shall be smoothened with a trowel or float, if necessary, with the addition of sugar solution and lime putty. The sugar solution may be prepared in any one of the following ways as directed by the Engineer.

a) By mixing about 3 Kg of Jaggery and 1.5 Kg of BAEL fruit to 100 litres of water.

b) By mixing about 600 gm of KADUKAI (the dry nuts shall be broken to small pieces and allowed to soak in water), 200 gm of jaggery and 40 litres of water for 10 sq.m of work. This solution shall be brewed for about 12 to 24 hours and the resulting liquor decanted and used for the work.

The lime concrete after compaction shall be cured for a minimum period of seven days or until it hardens by covering with a thin layer of straw or hessian which shall be kept wet continuously.

Machine made flat terracing tiles shall be of the size and thickness as specified. Tiles shall be soaked in water for at least one hour before laying. Bedding for the tiles shall be 12mm thick in cement mortar 1:3. Tiles shall be laid, open jointed with 4 to 6 mm wide joints, flat on the mortar and lightly pressed and set to plane surface true to slope, using a trowel and wooden straight edge. They shall be laid with their longitudinal lines of joints truly parallel and generally at right angles to the direction of run-off gradient. Transverse joints in alternate rows shall come directly in line with each other. Transverse joints in adjacent courses shall break joints by atleast 50 mm. The joints shall be completely filled and flush pointed with cement mortar 1:2 mixed with water proofing compound as per manufacturer's instructions. Curing shall be carried out for a minimum period of seven days.

Finishing on top with cement concrete tiles or in-situ cement concrete floor topping shall be carried out in similar fashion as described for clay tiles in above the paragraph. Tiles to be used shall be supplied after the first machine grinding of the surface.

8.25.4 Measurement

Measurement shall be in sq.m correct to two places of decimal. Measurement shall be for the plan area where the treatment is executed. No separate payment shall be made for the fillets.

8.25.5 Waterproofing of Roofs/Terraces etc.

8.25.5.1 Water proofing of Horizontal Surfaces

The waterproofing shall be applied as follows:

A coat of Blown Bitumen 85/25 shall be applied at the rate of 1.45 kg/sq.km

A roll of Modified Bituminous Membrane shall be unrolled over the primed surface and completely bonded to the substrate by pressing down evenly for the full width of the roll using a wooden roller. Torching shall be done, where recommended by the manufacturer and where directed by the Engineer-in-Charge, as the unrolling progresses.

The side overlaps shall be minimum 100 mm whereas the end overlaps shall be minimum 150 mm; both shall be bonded and sealed by flame torching.

Care shall be taken that the membrane is lapped with the treatment along the vertical surface and roof gutter treatment for at least 500 mm.

The membrane shall be properly overlapped/terminated at all openings, rainwater downtakes etc. to ensure that such junctions do not become sources of leakage.

Top of membrane finally shall be painted with antiglouse reflective paint.

8.25.5.2 Waterproofing of Vertical Surfaces at Roof Level and Gutters

The Water proofing shall be applied as described in (a) above.

Modified Bituminous membrane shall be unrolled and bonded to the substrate after applying a coat of bitumen and by pressing down evenly for the full width of the roll. Light torching shall be done to ensure complete bonding.

The membrane shall be overlapped with treatment for the horizontal surface by at least 500 mm.

The membrane shall be taken upto a pre-cut chase anchored and sealed.

8.25.6 Khurras and Rainwater Down Pipes

Down pipes shall be isolated from RCC work with 6 mm polyethylene foam fixed with adhesive (Araldite) and sealed with silicone sealant prior to laying membrane. A water proofing flashing composed of one layer of Hessian based self finished felt Type 3 Grade 1 and two layers of aluminium foil of 0.075 mm thickness shall be provided. This flashing shall be carried into the down take pipes for at least 150 mm and sealed with hot bitumen. The Contractor shall closely coordinate the work with the agency providing and fixing the rainwater down take pipes.

8.25.7 Testing

The treated area (flat and horizontal only) shall be tested by allowed water to stand on the treated areas to a depth of 150 mm for a minimum period of 72 hours.

The treated area (flat and horizontal) shall have continuous slope towards the rainwater outlets and no water shall pond any where on the surface.

8.26 Cement Plastering Work

8.26.1 Materials

The proportions of the cement mortar for plastering shall be 1:4 (one part of cement to four parts of sand). Cement and sand shall be mixed thoroughly in dry condition and then just enough water added to obtain a workable consistency. The quality of water and cement shall be as per relevant IS standards. The quality and grading of sand for plastering shall conform to IS: 1542. The mixing shall be done thoroughly in a mechanical mixer unless hand mixing is specifically permitted by the Engineer. If so desired by the Engineer sand shall be screened and washed to meet the Specifications. The mortar thus mixed shall be used as soon as possible preferably within 30 minutes from the time water is added to cement. In case the mortar has stiffened due to evaporation of water this may be re- tempered by adding water as required to restore consistency but this will be permitted only upto 30 minutes from the time of initial mixing of water to cement.

Any mortar which is partially set shall be rejected and removed forthwith from the site. Droppings of plaster shall not be re-used under any circumstances.

8.26.2 Workmanship

Preparation of surfaces and application of plaster finishes shall generally conform to the requirements specified in IS: 1661 and IS: 2402.

Plastering operations shall not be commenced until installation of all fittings and fixtures such as door/window panels, pipes, conduits etc. are completed.

All joints in masonry shall be raked as the work proceeds to a depth of 10mm/20mm for brick/stone masonry respectively with a tool made for the purpose when the mortar is still green. The masonry surface to be rendered shall be washed with clean water to remove all dirt, loose materials, etc., Concrete surfaces to be rendered shall be roughened suitably by hacking or bush hammering for proper adhesion of plaster and the surface shall be evenly wetted to provide the correct suction. The masonry surfaces should not be too wet but only damp at the time of plastering. The dampness shall be uniform to get uniform bond between the plaster and the masonry surface.

Interior plain faced plaster - This plaster shall be laid in a single coat of 13mm thickness. The mortar shall be dashed against the prepared surface with a trowel. The dashing of the coat shall be done using a strong whipping motion at right angles to the face of the wall or it may be applied with a plaster machine. The coat shall be trowelled hard and tight forcing it to surface depressions to obtain a permanent bond and finished to smooth surface. Interior plaster shall be carried out on jambs, lintel and sill faces, etc. as shown in the drawing and as directed by the Engineer.

Plain Faced Ceiling plaster - This plaster shall be applied in a single coat of 6mm thickness. Application of mortar shall be as stipulated in above paragraph.

Exterior plain faced plaster - This plaster shall be applied in 2 coats. The first coat or the rendering coat shall be approximately 14mm thick. The rendering coat shall be applied as stipulated above except finishing it to a true and even surface and then lightly roughened by cross scratch lines to provide bond for the finishing coat. The rendering coat shall be cured for atleast two days and then allowed to dry. The second coat or finishing coat shall be 6 mm thick. Before application of the second coat, the rendering coat shall be evenly damped. The second coat shall be applied from top to bottom in one operation without joints and shall be finished leaving an even and uniform surface. The mortar proportions for the coats shall be as specified in the respective item of work. The finished plastering work shall be cured for atleast 7 days.

Interior plain faced plaster 20mm thick if specified for uneven faces of brick walls or for random/coursed rubble masonry walls shall be executed in 2 coats similar to the procedure stipulated in above paragraph.

Exterior Sand Faced Plaster- This plaster shall be applied in 2 coats. The first coat shall be approximately 14mm thick and the second coat shall be 6mm thick. These coats shall be applied as stipulated above. However, only approved quality white sand shall be used for the second coat and for the finishing work. Sand for the finishing work shall be coarse and of even size and shall be dashed against the surface and sponged. The mortar proportions for the first and second coats shall be as specified in the respective items of work.

Wherever more than 20mm thick plaster has been specified, which is intended for purposes of providing beading, bands, etc. this work shall be carried out in two or three coats as directed by the Engineer duly satisfying the requirements of curing each coat (rendering/floating) for a minimum period of 2 days and curing the finished work for atleast 7 days.

In the case of pebble faced finish plaster, pebbles of approved size and quality shall be dashed against the final coat while it is still green to obtain as far as possible a uniform pattern all as directed by the Engineer.

Where specified in the drawings, rectangular grooves of the dimensions indicated shall be provided in external plaster by means of timber battens when the plaster is still in green condition. Battens shall be carefully removed after the initial set of plaster and the broken edges and corners made good. All grooves shall be uniform in width and depth and shall be true to the lines and levels as per the drawings.

Curing of plaster shall be started as soon as the applied plaster has hardened sufficiently so as not to be damaged when watered. Curing shall be done by continuously applying water in a fine spray and shall be carried out for at least 7 days.

For waterproofing plaster, the Contractor shall provide the water-proofing admixture as specified in manufacturers instruction while preparing the cement mortar.

For external plaster, the plastering operations shall be commenced from the top floor and carried downwards. For internal plaster, the plastering operations for the walls shall commence at the top and carried downwards. Plastering shall be carried out to the full length of the wall or to natural breaking points like doors/windows etc. Ceiling plaster shall be completed first before commencing wall plastering.

Double scaffolding to be used shall be as specified in clause 8.2.2.

The finished plaster surface shall not show any deviation more than 4mm when checked with a straight edge of 2m length placed against the surface.

To overcome the possibility of development of cracks in the plastering work following measures shall be adopted.

a) Plastering work shall be deferred as much as possible so that fairly complete drying shrinkage in concrete and masonry works takes place.

b) Steel wire fabric shall be provided at the junction of brick masonry and concrete to overcome reasonably the differential drying shrinkage/thermal movement.

c) Ceiling plaster shall be done, with a trowel cut at its junction with wall plaster. Similarly trowel cut shall be adopted between adjacent surfaces where discontinuity of the background exists.

8.26.3 Measurement

Measurement for plastering work shall be in sq.m correct to two places of decimal. Unless a separate item is provided for grooves, mouldings, etc., these works are deemed to be included in the unit rates quoted for plastering work. The quantity of work to be paid for under these items shall be calculated by taking the projected surface of the areas plastered after making necessary

deductions for openings for doors, windows, fan openings etc. The actual plaster work carried out on jambs/sills of windows, openings, etc. shall be measured for payment.

8.27 Cement Pointing

8.27.1 Materials

The cement mortar for pointing shall be in the proportion of 1:3 (one part of cement to three parts of fine sand). Sand shall conform to IS: 1542 and shall be free from clay, shale, loam, alkali and organic matter and shall be of sound, hard, clean and durable particles. Sand shall be approved by Engineer and if so directed it shall be washed/screened to meet specification requirements.

8.27.2 Workmanship

Where pointing of joints in masonry work is specified, the joints shall be raked at least 15mm/20mm deep in brick/stone masonry respectively as the work proceeds when the mortar is still green.

Any dust/dirt in the raked joints shall be brushed out clean and the joints shall be washed with water. The joints shall be damp at the time of pointing. Mortar shall be filled into joints and well pressed with special steel trowels. The joints shall not be disturbed after it has once begun to set. The joints of the pointed work shall be neat. The lines shall be regular and uniform in breadth and the joints shall be raised, flat, sunk or 'V' as may be specified in the respective items of work. No false joints shall be allowed.

The work shall be kept moist for atleast 7 days after the pointing is completed. Whenever coloured pointing has to be done, the colouring pigment of the colour required shall be added to cement in such proportions as recommended by the manufacturer and as approved by the Engineer.

8.27.3 Measurement

The quantity of work to be paid for under this item shall be measured in sq.m. Correct to two places of decimal by taking the projected surface of the area pointed after making necessary deductions for openings, etc.

8.28 Metal Lath and Wire Fabric

8.28.1 Materials

Welded steel wire fabric shall conform to IS: 4948.

Expanded metal shall conform to IS: 412.

Galvanised wire mesh shall be of approved quality.

8.28.2 Workmanship

The type and details of the steel material to be used for metal lath plastering work and at the junctions of brick masonry/concrete before wall plastering shall be as specified in the respective items of work.

For metal lath plastering work, the weight of steel material shall be not less than 1.6 kg/sq.m.

Steel material for use at the junction of brick masonry/concrete shall have the mesh dimensions not greater than 50 mm.

Steel material shall be obtained in maximum lengths as manufactured to restrict joints to the minimum. Overlap at the joints shall be minimum 25 mm which shall be securely tied with wires of diameter not less than 1.25 mm at spacings not more than 100 mm for lath plastering work. Nailing to wall shall be at spacings not exceeding 200 mm. The material shall be straightened, cut and bent to shape if required for fixing as per the details indicated in the drawings.

8.28.3 Measurement

Measurement shall be in sq.m correct to two places of decimal for the type as specified in the respective items of work.

8.29 Water-Proofing Admixtures

Water-proofing admixture shall conform to the requirements of IS: 2645 and shall be of approved manufacture. The admixture shall not contain calcium chloride. The quantity of the admixture to be used for the works and method of mixing etc. shall be as per manufacturer's instructions and as directed by the Engineer.

8.30 Painting of Concrete, Masonry & Plastered Surfaces

8.30.1 Materials

Oil bound distemper shall conform to IS: 428. The primer shall be an alkali-resistant primer of the same manufacturer as that of the distemper.

Cement paint shall conform to IS: 5410. The primer shall be a thinned coat of cement paint.

Lead free acid, alkali and chlorine resisting paint shall conform to IS: 9862.

White wash shall be made from good quality fat lime conforming to IS: 712. It shall be slaked at site and mixed with water in the proportion of 5 litres of water to 1 kg of unslaked lime stirred well to make a thin cream. This shall be allowed to stand for a minimum period of one day and strained through a clean coarse cloth. Four kg of gum dissolved in hot water shall be added to each cum of cream. 1.30 kg of sodium chloride dissolved in hot water shall then be added per 10 kg of lime used for the white wash, making it ready for application.

Colour wash shall be made by addition of a suitable quantity of mineral pigment, not affected by lime, to the prepared white wash to obtain the shade/tint as approved by the Engineer.

All the materials shall be of the best quality from an approved manufacturer. Contractor shall obtain prior approval of the Engineer for the brand of manufacture and the colour/shade. All materials shall be brought to the site of works in sealed containers.

8.30.2 Workmanship

Contractor shall obtain the approval of the Engineer regarding the readiness of the surfaces to receive the specified finish, before commencing the work on painting.

Painting of new surfaces shall be deferred as much as possible to allow for thorough drying of the sub- strata.

The surfaces to be treated shall be prepared by thoroughly brushing them free from dirt, mortar droppings and any loose foreign materials. Surfaces shall be free from oil, grease and efflorescence. Efflorescence shall be removed only by dry brushing of the growth. Cracks shall be filled with Gypsum. Workmanship of painting shall generally conform to IS: 2395.

Surfaces of doors, windows etc. shall be protected suitably to prevent paint finishes from splashing on them.

8.30.3 White Wash

The prepared surfaces shall be wetted and the finish applied by brushing. The operation for each coat shall consist of a stroke of the brush first given horizontally from the right and the other from the left and similarly, the subsequent stroke from bottom upwards and the other from top downwards, before the first coat dries. Each coat shall be allowed to dry before the next coat is applied. Minimum of 2 coats shall be applied unless otherwise specified. The dry surface shall present a uniform finish without any brush marks.

8.30.4 Colour Wash

Colour wash shall be applied in the same way as for white wash. A minimum of 2 coats shall be applied unless otherwise specified. The surface shall present a smooth and uniform finish without any streaks. The finished dry surface shall not show any signs of peeling/powdery and come off readily on the hand when rubbed.

8.30.5 Cement Paint

The prepared surfaces shall be wetted to control surface suction and to provide moisture to aid in proper curing of the paint. Cement paint shall be applied with a brush with stiff bristles. The primer coat shall be a thinned coat of cement paint. The quantity of thinner shall be as per manufacturer's instructions. The coats shall be vigorously scrubbed to work the paint into any voids for providing a continuous paint film free from pinholes for effective water proofing in addition to decoration. Cement paint shall be brushed in uniform thickness and the covering capacity for two coats on plastered surfaces shall be 3 to 4 kg/sq.m. A minimum of 2 coats of the same colour shall be applied. Atleast 24 hours shall be left after the first coat to become sufficiently hard before the second coat is applied. The painted surfaces shall be thoroughly cured by sprinkling with water using a fog spray at least 2 to 3 times a day. Curing shall commence after about 12 hours when the paint hardens. Curing shall be continued for atleast 2 days after the application of final coat. The operations for brushing each coat shall be as detailed above.

8.30.6 Oil bound Distemper

The prepared surfaces shall be dry and provided with one coat of alkali resistant primer by brushing. The surface shall be finished uniformly without leaving any brush marks and allowed to dry for atleast 48 hours. A minimum of two coats of oil bound distemper shall be applied, unless otherwise specified. The first coat shall be of a lighter tint. Atleast 24 hours shall be left after the first coat to become completely dry before the application of the second coat. Broad, stiff, double bristled distemper brushes shall be used for the work. The operations for brushing each coat shall be as detailed above.

8.30.7 Acid, Alkali Resisting Paint

A minimum of two coats of acid- and alkali-resistant paint shall be applied over the prepared, dry surfaces by brushing. Primer coat shall be as per manufacturer's instructions.

8.30.8 Plastic Emulsion Paint

The prepared surface shall be dry and provided with one coat of primer which shall be a thinned coat of emulsion paint. The quantity of thinner shall be as per manufacturer's instructions. The paint shall be laid on evenly and smoothly by means of crossing and laying off. The crossing and laying off consists of covering the area with paint, brushing the surface hard for the first time over and then brushing alternately in opposite directions two or three times and then finally brushing lightly in a direction at right angles. In this process, no brush marks shall be left after the laying off is finished. The full process of crossing and laying off constitutes one coat. The next coat shall be applied only after the first coat has dried and sufficiently become hard which normally takes about 2 to 3 hours. A minimum of 2 finishing coats of the same colour shall be applied unless otherwise specified. Paint may also be applied using rollers. The surface on finishing shall present a flat velvety smooth finish and uniform in shade without any patches.

8.30.9 Acrylic Emulsion Paint

Acrylic emulsion paint shall be applied in the same way as for plastic emulsion paint. A minimum of 2 finishing coats over one coat of primer shall be provided unless otherwise specified.

8.30.10 Measurement

Measurement shall be in sq.m correct to two places of decimal. Measurement shall be for the areas as executed duly deducting for any openings etc. Rate quoted shall take into account the provision of necessary enabling works such as scaffolding, painter’s cradle etc.

8.31 Painting & Polishing of Wood Work

8.31.1 Materials

Wood primer shall conform to IS: 3536.

Filler shall conform to IS: 110.

Varnish shall conform to IS: 337.

French polish shall conform to IS: 348.

Synthetic enamel paint shall conform to IS: 2932.

All the materials shall be of the best quality from an approved manufacturer. Contractor shall obtain prior approval of the Employer’s Representative for the brand of manufacture and the colour/shade. All materials shall be brought to the site of works in sealed containers.

8.31.2 Workmanship

The type of finish to be provided for woodwork of painting or polishing, the number of coats, etc. shall be as specified in the respective items of work to be prepared by the Contractor.

Primer and finish paint shall be compatible with each other to avoid cracking and wrinkling. Primer and finish paint shall be from the same manufacturer.

Painting shall be either by brushing or spraying. Contractor shall procure the appropriate quality of paint for this purpose as recommended by the manufacturer. The workmanship shall generally conform to the requirements of IS: 2338 (Part I).

All the wood surfaces to be painted shall be thoroughly dry and free from any foreign matter. Surfaces shall be smoothened with abrasive paper using it across the grains and dusted off. Wood primer coat shall then be applied uniformly by brushing. The number of primer coats shall be as specified in the item of work to be prepared by the Contractor. Any slight irregularities of the surface shall then be made- up by applying an optimum coat of filler conforming to IS: 110 and rubbed down with an abrasive paper for obtaining a smooth surface for the undercoat of synthetic enamel paint conforming to IS:2932. Paint shall be applied by brushing evenly and smoothly by means of crossing and laying off in the direction of the grain of wood. After drying, the coat shall be carefully rubbed down using very fine grade of sand paper and wiped clean before the next coat is applied. Atleast 24 hours shall elapse between the application of successive coats. Each coat shall vary slightly in shade and this shall be got approved by the Employer's Representative. The number of coats of paint to be applied shall be as specified in the item of work to be prepared by the Contractor.

All the wood surfaces to be provided with clear finishes shall be thoroughly dry and free from any foreign matter. Surfaces shall be smoothened with abrasive paper using it in the direction of the grains and dusted off. Any slight irregularities of the surface shall be made up by applying an optimum coat of transparent liquid filler and rubbed down with an abrasive paper for obtaining a smooth surface. All dust and dirt shall be thoroughly removed. Over this prepared surface, varnish conforming to IS:337 shall be applied by brushing. Varnish should not be retouched once it has begun to set. Staining if required shall be provided as directed by the Employer's Representative. When two coats of varnish is specified, the first coat should be a hard-drying undercoat or flatting varnish which shall be allowed to dry hard before applying the finishing coat. The number of coats to be applied shall be as specified. For works where clear finish of French polish is specified the prepared surfaces of wood shall be applied with the polish using a pad of woolen cloth covered by a fine cloth. The pad shall be moistened with polish and rubbed hard on the surface in a series of overlapping circles to give an even finish over the entire area. The surface shall be allowed to dry before applying the next coat. Finishing shall be carried out using a fresh clean cloth over the pad, slight dampening with methylated spirit and rubbing lightly and quickly in circular motions. The finished surface shall have a uniform texture and high gloss. The number of coats to be applied shall be as specified.

8.32 Painting of Steel Work

8.32.1 Materials

Red-oxide – zinc chrome primer shall conform to IS: 2074.

Synthetic enamel paint shall conform to IS: 2932.

Aluminium paint shall conform to IS: 2339.

All the materials shall be of the best quality from an approved manufacturer. Contractor shall obtain prior approval of the Employer's Representative for the brand of manufacture and the colour/shade. All the materials shall be brought to the site in sealed containers.

8.32.2 Workmanship

Painting work shall be carried out only on thoroughly dry surfaces. Painting shall be applied either by brushing or by spraying. Contractor shall procure the appropriate quality of paint for this purpose as recommended by the manufacturer. The workmanship shall generally conform to the requirement of IS: 1477 (Part 2).

The type of paint, number of coats etc. shall be as specified in the respective items of work.

Primer and finish paint shall be compatible with each other to avoid cracking and wrinkling. Primer and finish paint shall be from the same manufacturer.

All the surfaces shall be thoroughly cleaned of oil, grease, dirt, rust and scale. The methods to be adopted using solvents, wire brushing, power tool cleaning etc., shall be as per IS: 1477 (Part – I) and as indicated in the item of work.

It is essential to ensure that immediately after preparation of the surfaces, the first coat of red oxide-zinc chrome primer shall be applied by brushing and working it well to ensure a continuous film without holidays. After the first coat becomes hard dry, a second coat of primer shall be applied by brushing to obtain a film free from `holidays'.

After the second coat of primer is hard dry, the entire surface shall be wet rubbed cutting down to a smooth uniform surface. When the surface becomes dry, the undercoat of synthetic enamel paint of optimum thickness shall be applied by brushing with minimum of brush marks. The coat shall be allowed to hard-dry. The under coat shall then be wet rubbed cutting down to a smooth finish, taking adequate care to ensure that at no place the undercoat is completely removed. The surface shall then be allowed to dry.

The first finishing coat of paint shall be applied by brushing and allowed to hard-dry. The gloss from the entire surface shall then be gently removed and the surface dusted off. The second finishing coat shall then be applied by brushing.

Atleast 24 hours shall elapse between the application of successive coats. Each coat shall vary slightly in shade and this shall be got approved by the Employer's Representative.

8.33 Flashing

8.33.1 Materials

Anodised Aluminium sheets shall be 1.00mm thick with anodic film thickness of 0.025 mm.

Galvanised mild steel sheets shall be 1.00mm thick with zinc coating of 800 gms/sq.m.

Bitumen felt shall be either Hessian base self finished bitumen felt Type-3 Grade I conforming to IS:1322 or glass fibre base self finished felt Type-2 Grade 1 conforming to IS:7193.

8.33.2 Workmanship

The type of the flashing and method of fixing shall be as specified.

Flashing shall be of the correct shape and size as indicated in the construction drawings and they shall be properly fixed to ensure their effectiveness.

Flashing shall be of long lengths so as to provide minimum number of joints. The minimum overlap at joints shall be 100mm.

Fixing of the flashing shall be either by bolting with bitumen washers or by tucking into the groove 75 mm wide x 65 mm deep in masonry/concrete along with cement mortar 1:4 filletting as indicated in the Drawings. Curing of the mortar shall be carried out for a minimum period of 4 days.

Bitumen felt flashing of the type as specified shall be provided with 2 coats of bituminous paint at the rate of 0.10 litre/sq.m after the installation.

8.33.3 Measurement

Measurement shall be in sq.m correct to two places of decimal. Measurement shall be for the actual area of the flashing material provided and the rate shall include for all the incidental works of bending to shape and fixing details as per the construction drawings.

8.34 Thermal Insulation for Ceiling

Thermal insulation shall be "Thermocole" TF type or similar approved or resin-bonded fiberglass boards.

8.34.1 Fixing

8.34.2 "Thermocole" Boards

Soffit of R.C. slab shall be thoroughly cleaned with a wire brush, and 85/25 industrial grade hot bitumen conforming to IS: 702 shall be applied uniformly over the surface at the rate of 1.5 Kg/m^2.

Thermocole boards (T.F. variety) of 50mm thickness shall be stuck by means of the same grade of hot bitumen.

The boards shall be further secured with screws, washers and plugs.

The joints of the boards shall be sealed with bitumen.

8.34.3 Fibre Glass Boards

Timber pegs 50mm x 50mm x 50mm shall be fixed to the slab at 600mm centres with 6mm x 65mm long wood screws. 20 gauge G.I. lacing wire shall be tied to the pegs.

`Crown' 200 fiberglass boards 50mm thick shall be stuck to the pegs with CPRX compound or any other suitable adhesive and be held in position by the 20 gauge G.I. lacing wires.

The insulation boards shall be covered with 20mm – 24 gauge hexagonal G.I. chicken wire mesh, nailed to the timber pegs and 30 gauge aluminium sheets shall be fixed over the chicken wire mesh with 50mm overlap and secured to the timer pegs by screws.

If the insulation is specified to rest on top of the false ceiling, it shall be properly installed and anchored to the framework. In case additional battens are required for proper installation, Contractor shall include its cost in the rate for insulation.

8.34.4 Measurement

The net superficial area of the insulation shall be measured and paid for.

8.35 Plaster of Paris Board False Ceiling

8.35.1 Plaster of Paris Boards

The plaster of paris boards to be used in the false ceiling shall be of an approved manufacture or manufactured at site by methods and materials approved by Engineer.

The plaster of paris shall be of the calcium-sulphate hemi-hydrate variety and shall contain not less than 35 percent sulphur trioxide and other requirements as per IS:2547 (Part I). However, its fineness shall be such that the residue, after drying, and sieving on I.S. sieve designation 3.35mm for 5 minutes shall not be more than 1 percent by weight. Initial setting time shall not be less than 13 minutes. The average compressive strength of plaster determined by testing 5 cm cubes 24 hours after removal from moulds and drying in an oven at 40 Deg. C till the weight of the cubes is constant, shall not be less than 84 kg per sq.cm.

The plaster of paris boards reinforced with hessian cloth or coir shall be prepared in suitable sizes as shown on the drawings or as directed by the Engineer. Wooden forms of height equal to the thickness of boards shall be placed on truly level and smooth surface such as a glass sheet. The edges of the boards shall be truly square. The glass sheet or surface on which form is kept and the form sides shall be given a thin coat of non-staining oil to facilitate the easy removal of the board. Plaster of paris shall be evenly spread into the form upto about half the depth and hessian cloth or coir shall be pressed over the plaster of paris layer. The weight of hessian cloth or coir in the board shall be 250 gm per sq.m. The ends of the hessian/coir reinforcement shall be turned over at all edges to form a double layer for a width of 50mm. The hessian cloth shall be of an open web texture so as to allow the plaster below and above to intermix with each other and form an integral board. The form shall then be filled with plaster of paris which shall be uniform pressed and then wire cut to an even and smooth surface. The board shall then be allowed to set initially for an hour or so and then removed from the form and allowed to dry and harden for about a week. The board after drying and hardening shall give a ringing sound when struck. The boards shall be true and exact to shape and size and the exposed face shall be truly plane and smooth.

The size of boards shall generally be 600mm x 600 mm x 12 mm thick. Boards shall be kept dry in transit and stored flat in a clean dry place and shall not be exposed to moisture. The boards shall always be carried on edges.

8.35.2 Metal Framework

The metal frame work may be made of sections of light metal, such as anodised aluminium, mild steel or as shown on the drawings. The shape of cross-section shall be such as to facilitate proper suspension and proper fixing of the ceiling boards covering them and shall be structurally sound and rigid.

8.36 Construction

Contractor shall ensure that the frame to support the ceiling is designed for structural strength and the sizes, weight and strength of ceiling boards to be fixed and other loads due to live load, air-conditioning ducts, grills, electrical wiring and lighting fixtures, thermal insulation, etc. as shown on the drawings. Contractor shall also submit a detailed drawing to show the grid work, sizes of grid members, method of suspension, position of openings for air-conditioning and lighting, access doors, etc.

The false ceiling grid work shall be carried out as per the approved drawings or as directed by Engineer. In case of timber grid work, the grid work shall consist of teak wood runners of minimum size 60mm deep x 40mm wide along one direction at 1.2m centre to centre and secondary runners of size 50mm deep x 40 mm wide at 60mm centre to centre perpendicular to the main runners.

The metal frame work when it is anodised aluminium false ceiling grid system shall consist of aluminium main member of special T-Profile of 38mm x 38mm x 1.5mm thick, interlocking with each other to form frames of various sizes, 600mm x 600 mm or as shown on the drawing. The main members shall be suspended from the roof structures by means of steel hangers as described for timber frame work and supported at the walls by means of anodised aluminium wall angles.

In the case of timber frame work, all the edges of the plaster of paris board shall be fixed to frame members by means of counter sunk and rustless screws of 2.74 mm size, 40mm long at a spacing of 100mm to 150 mm c/c and 12mm from the edge of the board. Holes for screws shall be drilled and screws slightly countersunk into the boards. The boards shall be fixed to wooden framework with a joint clearance of about 3mm. The joints shall always be in perfect line and plane.

In case of aluminium grid system, boards shall be just placed into the frames formed by the main `T' members and the cross members fitted with the clips for locking boards. Contractor shall take utmost care so as not to force the boards in position and a slight gap shall be provided so as not to make a tight joint. The boards shall be cut with a saw, if required, to any shape and size.

As the work of false ceiling may be inter-connected with the work of air-conditioning ducts and lighting, Contractor shall fully co-operate with the other agencies entrusted with the above work, who may be working simultaneously. Contractor shall provide necessary openings in the false ceiling work for air-conditioning, lighting and other fixtures. Additional framing, if required, for the above opening shall also be provided at no extra cost to the Employer. Removable or hinged type inspection or access trap doors shall be provided at locations specified by the Engineer.

8.36.1 Finishing

It is essential that false ceiling work should be firm and in perfect line and level and all boards free from distortion, bulge, and other defects. All defective boards and other material shall be removed from site immediately and replaced, and ceiling restored to original finish to the satisfaction of Engineer.

The workmanship shall be of highest order and all joinery work for timber work shall be in the best workmanship manner. The joints for aluminium frame work shall be of inter-locking type so that when the cross member is in place, it cannot be lifted out.

The countersunk heads of screws and all joints shall be filled with plaster of paris and finished smooth. After filling the joints, a thick skin of the finishing material shall be spread about 50mm wide on either side of the joint and on to it shall be trowelled dry a reinforcing scrim cloth about 10mm wide. If metal scrim is used, a stiffer plaster will be necessary to enable the trowelling of the scrim down to the board.

8.36.2 Fire Stopping

In case of fire protective ceilings, fire resisting barriers at suitable intervals shall be provided. These shall completely close the gap between the false ceiling and soffit of the structural slab. The material of the barrier shall be as indicated by Engineer (Reference may be made to the British Standards Institutions CP 290: Code of Practice for suspended ceiling and lining of dry construction using metal fixing system, `for guidance).

8.36.3 Measurement and Payment

The superficial area of false ceiling shall be measured and paid for at the unit rate less deductions, if any. Openings in false ceiling which are less than 0.4 sq.m. in area shall not be deducted for the purpose of payment.

The quoted rates shall include supply, delivery and erection of all materials for covering the ceiling, frame work suspenders or hangers, anti-termite treatment making openings in false ceiling, extra frame work required for the openings, supporting the main members on masonry walls, levelling and finishing complete.

Where moulding or beading is specified, it shall be as per details shown in drawings and shall be measured in running metres and paid for separately.

Where fire barriers are specified, they shall be as per details shown in drawings and as directed and shall be measured in square metres and paid for separately.

8.37 False or Cavity Floor

8.37.1 Frame Work

The false floor shall consist of a framework of suitable structural member designed to carry the loads specified. This frame work shall be supported on suitably designed stools placed at 600mm centre to centre in both directions. The stools shall consist of a mild steel base plate with a mild steel stud having adjustable lock nut and coupling at the centre and another mild steel plate at top serving as a prophead. The above framework shall be suitably designed to accommodate 35mm thick, 600mm square panels. The base plate shall be fixed to the reinforced concrete floor with an approved adhesive compound or with 4 Nos. 6mm dia. anchor fasteners. Bedding of 1:2 or richer cement sand mortar shall be provided locally under the base plates of stools to provide a level surface.

The prophead shall be provided with mild steel lugs welded on top and each placed perpendicular to the other for proper positioning and supporting the main and cross members. The stools shall be capable of adjustment to accommodate concrete floor level irregularities upto plus or minus 15mm. The framing members shall be completely removable and shall remain in position without screwing or bolting to the propheads. All steel framework including steel stools shall be given a coat of zinc chromate primer and two coats of enamel paint of approved colour and shade.

8.37.2 Floor Panels

The floor panels shall be made of 600mm x 600mm x 35 mm thick medium density unveneered/ non-prelaminated teak wood particle boards having a density of not more than 800 kg/cum bonded with boiling water proof phenol formaldehyde synthetic resin and shall be of fire resistant, termite resistant and moisture proof quality, generally conforming to IS: 3087-specification for wood particle boards (Medium Density) for general purposes.

The thermal conductivity of the boards shall not exceed 0.12 k Cal/hr/sq.m/deg./C/m.

The panel size given above may be suitably modified near electrical panel/equipment and also to suit room dimensions with panel size not more than 600mm under any circumstances. Exposed 2mm thick vinyl edging shall be provided on all edges of individual panels. Each panel shall be given a coat or primer and two coats of approved fire-resistant paint from underside.

The particle boards shall be faced with 600mm x 600 mm x 2mm thick approved make flooring tiles conforming to IS:3462 and of approved colour and shade. The completed panel shall be completely removable and shall remain in position without screwing or bolting to the supporting framework. Each floor panel shall be marked on the inner side with stickers for easy identification and reassembly whenever required.

Suitable backing material shall be provided on the underside of the particle board to prevent warping and / or to cater to specified loading.

Floor panels made of 600mm x 600mm x 35 mm thick Steel Cementitious laminated panels can also be used with suitable supporting system.

Suitable removable covers shall be provided to serve as outlets for the cables.

8.37.3 Finished Height of False Flooring

The finished height from top of reinforced concrete floor to the finished floor surface of false/cavity floor shall be as specified or as shown on drawings.

8.37.4 Ramps and Steps

Ramps and steps shall be provided as shown on the Engineer's drawing and as directed by the Engineer without any extra cost to the Employer.

8.37.5 Imposed Loading

The finished floor shall be capable of supporting uniformly distributed loads of 500 to 1000 Kg. per sq.metre of floor area as specified in data sheet. A point load of 450 Kg on 600 sq.mm on any part of the panel or a line load of 725 Kg on 100mm strip across the panel length shall not result in a deflection greater than 2.5mm.

8.37.6 Finish

The finished floor shall be true to lines and levels and present a neat flush surface.

8.37.7 General

Supply shall be made by a specialist supplier who is to be approved by Engineer. Supplier shall prepare and submit a layout drawing for false floor giving all details including supporting system for approval. If so called for, supplier shall also submit his calculations for the supporting system

with all relevant data assumed, to the Engineer for his approval. Work shall be carried out on approved drawings only.

8.37.8 Measurement

The superficial area of false floor shall be measured and paid for at the quoted unit rate.

8.38 Vendor Drawing

Vendor shall prepare and submit a layout drawing for false floor giving all details including supporting system for approval. If so called for, vendor shall also submit his calculations for the supporting system with all relevant data assumed, to the Employer's Representative for his approval. Work shall be carried out on approved drawings only.

8.39 Fire Proof Doors

8.39.1 Material and Workmanship

The design of fire proof doors and the materials to be used in their fabrication have to be such that they shall be capable of providing the effective barrier to the spread of fire. The materials, fabrication and erection of fire proof doors shall confirm to IS: 3614 (Part – I). The fire proof doors shall be obtained from an approved manufacturer. Specific approval for such purchase shall be obtained before hand. Sample approval shall also be obtained from testing authority as per the standard IS: 3614 (Part – 2) for the specified degree of fire rating in hours. All fire proof doors shall have specified sizes and confirm to the description in the respective items of work.

Fire proof door shutters shall be of zinc coated weldable steel (confirming to BS: 6687) or stainless steel (conforming to IS: 304) sheet (18G minimum) fixed in a frame work of rolled channel. The shutter shall consist of an insulating material like mineral wool in required thickness to satisfy the specified fire rating. Normally the thickness of door shutter shall not be less than 35mm for two-hour fire rating and 46 mm for four-hour fire rating.

The shutter with the required insulating material shall be mounted on angle iron frame or the special made frame from zinc coated (16G minimum) weldable steel sheet. The shutter shall be fixed to frame by means of suitable hinges and shall have a three-way latching system. All the doors shall be provided with a coat of primer and one coat of synthetic enamel paint to attain the specified fire rating. All other accessories like hinges, door lock, hold fasts, etc. shall be provided as approved by TAC (Tariff Advisory Committee). All these accessories shall be compatible with the material used for door and shutter.

8.40 Hand Rails

All hand railing shall be provided with Aluminum Extrusion tubes having alloy AA6082 Temper T6 or AA 6063 T6 with an ultimate tensile strength of at least 207 MPa and yield strength of at least 172 MPa. The minimum height of hand railing shall be 1m and maximum spacing of verticals shall be 1.5 m- Number of horizontal rails shall be 3 with a 100mm x 2.5mm toe plate at the bottom.

Top Rail shall be from 32NB (42.16 mm OD) tube of schedule 40(3.50mm thk), while 2 no of mid rail shall be of 25NB (33.4mm OD) Schedule 40 tube. Post tube shall be 32NB (42.16mm

OD) Schedule 80 (4.80mm thk min). Toe guard of min 100mm height & having sufficient rigidity extruded out of min 2.5mm Thk alloy AA 6063 Temper T6.

welding not allowed for fabrication of handrails. Assembly and fabrication of Handrail shall be done by using Structural Fittings, manufactured from Aluminium Alloy 356/LM 25 with heat treatment (min UTS of alloy -280 N/mm2) confirming to ASTM B 108, ASTM B 26/ BS 1490. Aluminium Structural fittings shall be dynamically tested for permissible deflections while applying 74 kg / Linear Meter of UDL & 90 kg point load as per methodology mentioned in ASTM E 935.

Handrail shall be fixed on RCC surface with Mechanical or Chemical Anchor fasteners and shall be of SS or HDG and all fittings and pipes shall be prefinished as per IS 1868. The drawings to be submitted to the engineer for approval.

End of Chapter-8

CHAPTER 9

WELL SINKING

CHAPTER 9

WELL SINKING

9.1 General

Well sinking shall be proposed for Wetwell, in water logged conditions or water table near FGL.

9.2 Earthwork in Excavation

The earthwork shall be in accordance with chapter 3. The safety measures to be taken for excavations for open foundations shall be as per guidance laid down in IS 3764.

9.3 Well Sinking

The Construction and sinking of well shall in general follow provisions of IRC 78-2014-Section VII – Foundations and substructure. The latest editions of this code of practice including all applicable official amendments and revision shall be followed. In case of discrepancy between this specification and that referred in code, the specifications will govern.

9.3.1 Setting Out

Necessary reference points shall be fixed, away from the zone of blow-ups or possible settlements resulting from well sinking operations. These reference points shall be connected to the permanent stations with the base line on the banks. The centre of the individual wells shall be marked with reference to these stations.

9.3.2 Equipment

The following equipments are generally used for the work

(a) Crane with grab buckets - capacity 0.5 to 2.0 cum
(b) Chisels of appropriate sizes
(c) Aqua header for cutting rocky strata
(d) Diving helmets and accessories
(e) Equipment for concrete production, transportation, placing & compaction

9.3.3 Cutting Edge

The mild steel cutting edge shall be made from structural steel section with weight not less than 40 kg/m length and properly anchored into the well curb. The parts of the cutting edge shall be erected on level, firm ground. Temporary support shall be provided to facilitate the erection and maintenance of the assembly in its true shape. The fabrication may be carried out in the shop or at site. Steel sections shall not be heated and forced into shape. However, “V” cuts may be made in the horizontal portion, uniformly throughout the length, to facilitate cold bending. After bending such ‘V’ cuts should be closed by welding. Joints in the lengths of structural sections, unless otherwise specified shall be fillet welded using single cover plate to ensure the requisite strength of the original section. The cutting edge must be suitably stiffened

using plate stiffeners spaced at not more than 1.5m c/c along the periphery of cutting edge. The adequacy of the strength and the efficiency of performance of cutting-edge shall be specifically checked by the Contractor and necessary alterations made if required at his own responsibility. The weight of stiffeners shall not be considered in the weight of the cutting edge.

9.3.4 Well Curb

Well curb shall be of cast-in-situ concrete. The outer face of the curb shall be vertical. The bottom ends of vertical bond rods of steining shall be fixed securely to the cutting edge with check nuts or by welds. The form work on the outer face of the curb may be removed within 24 hrs after concreting. The formwork of the inner face shall be removed after 72 hrs. All the concreting in the well curb shall be done in one continuous operation. The curbs should be cast truly in position, and if construction of any cofferdam is required, it shall be done by the Contractor at his own cost.

9.4 Well Steining

The dimensions, shape, concrete strength and reinforcements of the well shall strictly conform to those shown in the drawings. The form work shall preferably be of M.S. sheets shaped and stiffened suitably. In case timber forms are used, they shall be lined with plywood or M.S. sheets.

Steining built in the first lift above the well curb shall not be more than 2 meters. For stability, the first lift of steining shall be cast only after partially sinking the curb. Concreting of steining may be carried out in subsequent lifts of about 2 meters. Attempts should be made to minimise the number of construction joints. The construction joint details shall be as shown in the drawing, and the receiving surfaces of the construction joint shall be thoroughly cleaned and prepared using air and water jets before the next lift is poured. The concreting layers shall be limited to about 450 mm restricting the free fall of concrete to not more than 2 m. Laitance formed at the top surface of a lift shall be removed to expose coarse aggregates before setting of concrete at the proposed construction joint. To the extent possible, construction joints shall not be located at the site of laps in the vertical steining bars.

The steining of the well shall be built in one straight line from bottom to top such that if the well is tilted, the next lift of steining will be aligned in the direction of the tilt. The work will be checked carefully with the aid of straight edges of lengths approved by the Engineer. Plumb bob or spirit level shall not be used for alignment. After the sinking of a stage is complete, any damaged portions of the steining at the top of the previous stage shall be properly repaired before constructing the next stage.

The height of steining shall be calibrated by making at least four gauges (preferably in direction along centre line of bridge and in a direction normal to the centre line of bridge) distributed equally on the outer periphery of the well each in the form of a 100 mm wide strip painted (preferably red colour) on the well, with every half a meter mark shown in black paint (mark thickness shall be 5mm). The gauges shall start with zero at the bottom of the cutting edge. Marking of the gauges shall be done carefully with a steel tape.

After reaching the founding level, the well steining shall be inspected to check for any damage or cracks. The Engineer will direct and the Contractor shall execute the remedial measures before acceptance of the well steining. If the well cannot be accepted despite any remedial measures, it shall be rejected.

Sinking of well should not be started till the steining has cured for at least 48 hours. The curing of well shall be continued upto 14 days from the day of concreting. Curing can be achieved through the use of water or through any approved curing compound.

Any honeycombed portion and leakage observed in the steining shall be repaired at the Contractor's own cost to the satisfaction of the Engineer.

9.4.1 Bottom Plug

The concrete mix shall be designed (in dry condition) to attain the concrete strength as mentioned in drawing, and shall contain 10% more cement content than that required for the same mix placed dry, to cater for under water concreting. However, the total cement content shall not be less than 360 kg/cum of concrete with a slump in the range of 150 mm to 200 mm. Admixture may be added to concrete to impart the required strength. The water cement ratio shall not exceed 0.5 and the slump of concrete shall be minimum 150mm. The diameter of tremie pipe shall not be less than 200 mm.

Concrete for the bottom plug shall be laid by Tremie pipe method. Tremie concrete once started shall be continued without interruption for full concreting in the bottom plug. Before commencing plugging, all loose material from the bottom of the well shall be removed and the inside faces cleaned thoroughly.

Concreting shall be done in one continuous operation till the dredge hole is filled upto the required height and thereafter sounding shall be taken to ensure that the concrete has been laid to the required height.

Least disturbance shall be caused to the water inside the well while laying concrete in the bottom plug and concrete shall not be disturbed in any way for atleast 14 days. To check any rise in the level of bottom plug, soundings should be taken at the close of concreting and once every day for the subsequent 3 days.

The soundness of bottom plug should be tested by de-watering the well by 5 meters below the surrounding water level and checking the rise of water. The rate of rise shall preferably be less than 10 cm/h. In case the rate is higher, remedial measures as directed by the Engineer should be taken by the Contractor at his own cost. The depth of the sump below the cutting for bottom plugging shall be 1/6th the diameter of the well. The Contractor shall take permission from Engineer before commencing the bottom plug. All necessary inspections like study of strata at the founding level, tilt, shift, etc. shall be communicated to the Engineer before bottom plugging. If any leakage of water is found, then necessary grouting of the plug and the junction of the well to control the same shall be carried out by the Contractor at no extra cost.

9.4.2 Sand Filling

Sand filling should be commenced after 14 days of laying the bottom plug. The height of bottom plug shall be rectified before starting sand filling. The sand should be clean and free from earth, clay, clods, roots, boulders, shingles etc. and should be backfilled in layers and consolidated by flooding.

9.4.3 Well Cap

The form work for the well cap should be prepared conforming to the shape of the well cap; concreting should be carried out in dry conditions. The bond rods of steining shall be properly anchored into the well cap.

9.5 Sinking of Well

Generally, the cutting edge is fabricated and connected to the concrete well curb. On top of the well curb, adequate height of well steining is cast and the process of sinking is carried out. After a portion of the well has been sunk, another height of well steining is cast on top of the previous section and further sinking carried out. The process is continued until the bottom level of the cutting edge reaches the foundation level.

The sinking of the well with use of kentledge shall be commenced only after the steining has been cured for at least 48 hrs. The well should not be placed in a pre-dredged hole. The sinking of the well shall be facilitated by excavating material uniformly from inside the dredge hole. Use of water jetting & divers may be adopted for sinking of well through harder strata with prior approval of the Engineer. The de-watering of well should not be used as a means for sinking of well. Contractor should take necessary precautions to avoid sand blows and he should be prepared at any point of time to tackle the sand blow problem, in case of any occurrence at no extra cost.

In the process of normal sinking any suitable method other than pneumatic sinking as necessary may be adopted. However, no claim due to any confirmations such as boulders, logs of trees met with during sinking or due to any other difficulty experienced in this process shall be entertained. The method to be adopted for sinking of well shall be approved by Engineer. For any change in method of sinking the Contractor shall obtain written permission from the Engineer-in-charge. During the operation of sinking of wells, the strata penetrated through and the behaviour of the well shall be reported to the Engineer. The Engineer's decision on any matter pertaining to sinking shall be final and binding on the Contractor.

As the dredging is in progress, soil samples for the study of soil parameters should be collected for every meter depth and the sample should be preserved as per the standard approved practice by the Contractor at no extra cost. The depth of sump in well at any level should not be more than one metre. Further the depth of sinking of well for a particular stage shall be restricted to 1 metre to avoid the sudden sinking of well i.e., jumping of well. A record of depth of dredging from the original bed level should be maintained right from the commencement of sinking of well.

If the well is sunk beyond the specified founding level without prior approval from the Engineer for any reason, the Contractor will not be entitled to any additional costs. In the event that the top of the well exceeds the required level due to unavoidable circumstances, it shall be the Contractor's responsibility to dismantle that portion of the work at their own cost. However, the matter should be discussed with the Engineer before any work in this regard is carried out.

9.5.1 Sinking History

The sinking history of well should be maintained in the format given in Appendix 1200/I of "Ministry of Road Transport & Highways - Roads & Bridges".

9.5.2 Use of Kentledge as Sinking Load

Kentledge shall be placed in an orderly and safe manner on the loading platform, ensuring it does not interfere with the excavation of material from inside the dredge hole and does not damage the steining of the well in any way. When tilts are present or there is a danger of well developing a tilt, the position of the load shall be regulated in such a manner as to provide greater sinking effort on the higher side of well.

9.5.3 Use of Divers

Use of divers may be made both for sinking purpose like removal of obstruction, excavation etc and for inspection. All safety precautions shall be taken as per applicable safety code for sinking with divers or any statutory regulations in force. Only persons trained for the diving operation shall be employed and shall be certified to be fit for diving by an approved doctor.

The diving and other equipment shall be of acceptable standard and certified to this effect by an approved independent agency. Arrangements for an ample supply of low-pressure, clean, cool air shall be ensured through an armored, flexible hose pipe. A standby compressor plant shall be provided in case of breakdown. All expenses incurred in use of divers, precautionary measures to be taken, casualties etc., will be at the Contractor's risk and own cost.

9.6 Precautions during Sinking

In case wells have to be sunk close to each other and clear distance between them is not greater than the diameter of well; sinking shall be taken up on all wells and they shall be sunk alternatively so that sinking of wells proceeds uniformly. Simultaneous and even dredging shall be carried out in wells in such a manner that the difference in the levels of the sump and cutting edge in the adjacent wells does not exceed half the clear gap between them. Preferably plugging of the wells close to each other can be done together.

Bore chart shall be referred to constantly during sinking for taking adequate care while piercing different types of strata. The type of soil as obtained during the well sinking should be compared with bore chart so as to take prompt decisions.

Before seasonal floods all wells sinking of which is in progress shall be sunk to sufficient depths below the designed scour level. Further they shall be temporarily filled and plugged so

that they do not suffer any tilt or shift during the floods. The Contractor can ask for any details related to hydraulics like HFL, LWL, scour depth etc., so as to plan his work suitably. Any losses incurred due to floods etc., by the Contractor due to improper planning of his work will be under Contractor's responsibility. No extra payment will be entertained in this regard.

All necessary precautions shall be taken against any possible damage to the existing foundations, prior to commencement of dredging from inside the well.

The dredged material shall not be allowed to accumulate over the well. It shall be dumped on the downstream and spread as far away as possible. In case the river stream flows along one edge of the well being sunk, the dredged material shall not be dumped on the dry side of the bank, but on the side on which the river current flows.

Very deep sump shall not be made below the well curb, as it entails risk of jumping (sudden sinking) of the well. The depth of sump shall be generally limited to $1/6^{th}$ of the outer diameter or 1m which ever is less.

In case a well sinks suddenly with a jerk, the steining of the well shall be examined to the satisfaction of the engineer to see that no damage has occurred to it.

De-watering shall be avoided if sand blows are expected. Any equipment and men working inside the well shall be brought out of the well as soon as there are any indications of a sand blow.

9.6.1 Tilts and Shifts

The tilt of any well shall not exceed 1 (horizontal) in 80 (vertical), and the shift at the well base shall not exceed 150mm in any resultant direction. Tilt's and shifts shall be carefully checked and recorded in the format given in Appendix 1207. of "Ministry of Road Transport & Highways - Roads & Bridges" regularly during sinking operations. For the purpose of measuring the tilts along the two axes of the bridge, the reduced level of the marks painted on the surface of the steeling of the well shall be taken. For the determination of the shift, the locations of the ends of the two diameters shall be precisely measured along the two axes, about fixed reference points.

The check for the occurrence of tilt should be made every day before the commencement of the work, and the readings/ findings should be properly recorded and maintained. The check for shift shall be done for every 1.5m of sinking of well. These recordings shall also be properly maintained.

Whenever any tilt is noticed, adequate preventive measures like placing eccentric kentledge, pulling, strutting, anchoring or dredging unevenly and depositing dredge material unequally, putting obstacles below cutting edge, water jetting etc. shall be adopted before any further sinking. After rectification, the dredging shall be uniform, and the dredged material shall be spread out uniformly. A pair of wells close to each other i.e., where clear distance between well is not greater than the diameter of well, they have tendency to come closer while sinking. Timber struts may be introduced in between the stonework of these wells to prevent tilting.

In the event of a well developing tilt or shift beyond the specified permissible values, the Contractor shall have to carry out, at his own cost, suitable remedial measures to the satisfaction of the Engineer, to bring the tilt and shift within the permissible values, as for as practicable.

If the resultant tilt and /or shift of any well exceed the specified permissible values, the well so sunk shall be regarded as not conforming to specification and a sub-standard work. Generally, it should not exceed 1 in 50 and 300 mm respectively. The Engineer in his sole discretion, may consider accepting such a well, provided the calculations for foundation pressure and steining stresses, accounting for the actual tilt and shift furnished by the Contractor show that well is safe. Any remedial measures required to bring the stresses within permissible values (such as increase in the dimension of the well cap, provision of dummy weights on the well cap) shall be carried out by the Contractor without claiming for any extra cost.

In case the Engineer, in his discretion rejects the well, the Contractor shall dismantle the rejected well to the extent directed by Engineer and remove the debris. Further the Contractor shall at his own risk and expense complete the bridge with modifications acceptable to the Engineer. The wells which are not conforming to the specified limits of tilts and shifts, if accepted for one or other reasons will be penalised in the form of lump-sum deductions per meter length of well which will be at the discretion of Engineer.

9.6.2 Seating of Well

The well shall be uniformly seated at the founding strata. After the well has been evenly seated on good hard rock, arrangements shall be made to facilitate proper inspection in dry and visible conditions before the bottom plug is laid. The founding levels shown in the drawings are purely based on the data available from geo-technical investigations. The Engineer on inspection will decide upon any modifications that may be required to meet the structural aspects. The bottom plugging shall be commenced only after this inspection and concurrence from Engineer.

9.6.3 Tolerances for Well Steining and Well Cap

The permissible tolerances are as follow:

(a)	Variation in dimension	:	+ 50mm - 10mm
(b)	Misplacement from specified position	:	15mm
(c)	Surface Irregularities measured with 3m straight edge	:	5mm
(d)	Variation of levels at the top	:	± 25mm

9.6.4 Measurement for Payment of Sinking of Well

The depth of sinking shall be measured from the natural bed level to the bottom of the well curb.

End of Chapter-9

PART 11

PARTICULAR TECHNICAL SPECIFICATIONS FOR CIVIL, STRUCTURAL AND PUMPING MAIN/SEWER NETWORK

CONTENTS

PART-11

PARTICULAR TECHNICAL SPECIFICATIONS FOR CIVIL, STRUCTURAL AND PUMPING MAIN/SEWER NETWORK

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PART-11

PARTICULAR TECHNICAL SPECIFICATIONS FOR CIVIL, STRUCTURAL AND SEWER NETWORK

A. Standard Basic Specifications

The "Standard Basic Specifications" Part-10 shall be followed for construction of General Works under this contract of BWSSB. Specifications for additional specialized items of civil works are as set out in Part 11, Particular Technical Specifications, of this Section.

In the event of any discrepancy between the provisions of the Standard Basic Specifications and the Particular Technical Specifications, the provisions of the Particular Technical Specifications shall prevail.

B. Particular Technical Specifications for WwTP, TSPS, ISPS & Connected Works

1.0 Design Submissions

Before proceeding with design and drawing preparation, the Contractor shall submit detailed general philosophy of design (Design Basis Report) of various parts of (all) the structures and equipment foundations along with explanatory sketches for review. Only after the review and incorporation of comments on the general philosophy, as offered during the review, the Contractor shall submit any design document and/or drawing for review and approval for construction.

1.1 Design Philosophy

Following are the details which are to be included in the general design philosophy document submission:

1. Design assumptions/philosophy for Liquid Retaining Structures with various boundary conditions as applicable.

2. Design assumptions/philosophy for buildings.

3. Design assumptions/philosophy for all other structures.

4. Standard General Notes shall include material properties (grade, strength, unit weight etc.), development lengths, lap/splice lengths, Anchorage lengths under tension and compression, clear cover, water proofing specifications, legend used etc.

1.2 Standard Details

Following typical details shall also be submitted for approval prior to proceeding with detailed design:

1. Reinforcement detail showing the development length at Column/Footing intersection, Column and Roof beam intersections, Walls and Base slab intersections, Walls and cover slab intersections.

2. Detailing of the reinforcement for columns, beams, beam/column intersection, footing/column intersection, and Slabs as per relevant code provisions/requirements depending upon the assumptions made in the design as applicable.

3. Reinforcement detail for cut-outs in slabs and walls with maximum size of cut-outs

4. Reinforcement detail at top of RCC trench walls showing edge/seating angles

5. Pouring sequence of concrete and standard details for construction joints, expansion joints, contraction joints, etc.

6. Details of Opening/holes and Rungs to be placed in the tanks.

7. Architectural drawings shall be submitted for all the buildings prior to submission of structural/RC drawings.

8. Detail for rain water drainage down take pipes at terrace slab and water proofing at roof/sunken slabs

9. Detail for storm water drain, Roads, plinth protection and entrance ramps to buildings

10. Detail for Handrails and fixing detail of handrail to concrete, Steel Ladders and fixing detail of ladders to Walls/Concrete, Cage ladders, Boundary walls, Fencing and Gates, etc.,

1.3 Submission

Contractor shall submit the detailed design and drawings only after items mentioned under clause 1.1 and 1.2 are approved or as directed by the Engineer

Complete detailed design calculations of foundations and superstructure together with general arrangement drawings and explanatory sketches shall be submitted to the Engineer. Separate design calculations for foundations or superstructures submitted independent of each other shall be deemed to be incomplete and shall not be accepted by the Engineer.

Submissions of detailed design calculations and Good for Construction drawings shall include the following as a minimum:

A. Detailed Design Calculations
    1. One (1) Copy of a Compact Disc (CD) containing electronic files relevant to the structure's modelling, analysis and design calculations (Microsoft Excel, STAADPro, etc.). Files submitted shall be in editable format.

    2. Print copy (7Copies) of the contents as submitted in the Compact Disc.

B. Good for Construction Drawings
    1. One (1) Copy of a Compact Disc (CD) containing AutoCAD files (Civil General Arrangement, Structural Dimensions and Reinforcement Details) pertaining to the structure. Files submitted shall be in editable format.

    2. Print copy (7Copies) of the contents as submitted in the Compact Disc. Prints to be submitted on A1 Size Sheet as a minimum or A0 Size Sheet when required by the employer.

    3. Bar-bending schedule indicating the number, shape and size of the rebars shall be submitted as part of the Reinforcement Details.

4. Detailed drawing showing the location, number and depth of inserts shall be included for any structural steel inserts/Metal inserts in the structure such as rungs, bolted connections for ladders/railings, etc.

5. Location of Construction Joints and pour sequence shall be included on the drawing for base slabs, walls and top slabs.

6. Revised drawings shall be submitted by clouding at the location with the latest revision number and also show the history of revisions in a table format just above the title block.

The design considerations described here under establish the minimum basic requirements of plain and reinforced concrete structures, masonry structures and structural steel works. However, any particular structure shall be designed for the satisfactory performance of the functions for which the same is being constructed. The Contractor shall also take care to check the stability of partly completed structures.

1.4 Design Standards

All the designs shall be based on the latest Bureau of Indian Standard (BIS) Specifications or Codes of Practice. The design standards adopted shall follow the best modern engineering practice in the field based on any other International Standard or specialist literature subject to such standard reference or extract of such literature in the English language being supplied to and approved by the Engineer. In case of any variation or contradiction between the provisions of the BIS Standards or Codes and the specifications given along with the tender document, the provision given in this Specification shall be followed.

All reinforced concrete structural design shall generally conform to the following publications of the Indian Standards Institution:

IS:456 : Code of Practice for plain and reinforced concrete
IS:875 : Code of Practice for design loads for buildings and structures (Part I to V)
IS:3370 : Code of Practice for concrete structures for the storage of liquids (Part I to IV)
IS:1893 : Criteria for earthquake resistant design of structures (Part 1to 4)
IS: 2974 : Code of Practice for design and construction of machine foundations (Part 1 to 4)
IS: 2911 : Code of practice for Design and construction of Pile foundations. (Parts 1 to 4)
IS:13920 : Ductile Detailing of Reinforced Concrete Structures subjected to Seismic forces-Code of Practice.
IS: 4326 : Code of Practice for Earthquake Resistant Design and Construction of Buildings
IRC: 6 : Standard specification and Code of Practice for road bridges Loads and Stresses
SP: 16 : Design Aids for Reinforced Concrete to IS 456
SP: 34 : Handbook on Concrete Reinforcement and Detailing.
SP: 23 : Handbook on Concrete Mixes.

All structural steel design shall generally conform to the following publications of the Indian Standards Institution:

I.S: 800 : Code of Practice for general construction in steel
I.S: 806 : Code of Practice for use of steel tubes in general building construction
SP: 38 : Handbook of Typified Design of Structures with Steel Roof Trusses

1.5 Design Life

The design life of all structures and buildings shall be 60 years.

1.6 Design Loadings

All buildings and structures shall be designed to resist the worst combination of the following loads/stresses under test and working conditions; these include dead load, live load, wind load, seismic load, stresses due to temperature changes, shrinkage and creep in materials, dynamic loads.

1.7 Dead Load

This shall comprise all permanent construction including walls, floors, roofs, partitions, stairways, fixed service equipment's and other items of machinery. In estimating the loads of process equipment all fixtures and attached piping shall be included, but excluding contents, shall be considered.
Dead loads shall be in general as per I.S. 875 Part (I). However, the following **minimum loads** shall be considered in design of structures:

(i)	Weight of water	9.81 kN/m^3
(ii)	Weight of soil (irrespective of strata available at site and type of soil used for filling etc). However, for checking stability against uplift, actual weight of soil as determined by field test shall be considered	20.00 kN/m^3
(iii)	Weight of concrete	24.00 kN/m^3
(iv)	Weight of reinforced concrete	25.00 kN/m^3
(v)	Weight of brickwork (exclusive of plaster)	22.00 N/m^2 per mm thickness of brickwork
(vi)	Weight of Solid Concrete Block work (exclusive of plaster)	24.00 N/m^2 per mm thickness of block work
(vii)	Weight of plaster to masonry surface	18.00 N/m^2 per mm thickness
(viii)	Weight of granolithic terrazzo finish or rendering screed, etc.	24.00 N/m^2 per mm thickness
(ix)	Weight of sand (filter media)	26.0 kN/m^3
(x)	Weight of alum blocks	24.20 kN/m^3

1.8 Live Load

Live Load (LL) shall include the superimposed loads due to the use/occupancy of the structure/building not including dead, wind or earthquake load. Live loads shall be in general as per I.S. 875 Part (II). However, the following **minimum live loads** shall be considered in the design of structures:

(i) Live load on roofs (accessible by staircase) : 1.50 kN/m^2

(ii) Live load on floors and walkways supporting equipment such as pumps, blowers, compressors, valves and all process related machinery etc. : 10.00 kN/m^2

(iii)	Live load on all other floors walkways, stairways and platforms	:	5.00 kN/m^2
(iv)	Live load on Toilet areas	:	2.00 kN/m^2
(v)	Surcharge for underground structures Including channels, sumps, cable & pipe trenches etc.	:	20.00 kN/ m^2

In the absence of any suitable provisions for live loads in BIS Codes or as given above for any particular type of floor or structure, assumptions made must receive the approval of the Engineer prior to starting the design work. Apart from the specified live loads or any other load due to material stored, any other equipment load or possible overloading during maintenance or erection/construction shall be considered and shall be partial or full whichever causes the most critical condition.

1.9 Wind Load

Wind loads shall be as per I.S. 875 Part (III).

1.10 Earthquake Load

This shall be computed as per I.S. 1893. An importance factor appropriate to the type of structure shall be considered for design of all the structures. For design of all Process buildings and structures an importance factor of 1.50 shall be adopted.

1.11 Dynamic Load

Dynamic loads due to working of plant items such as pumps, blowers, compressors, switch gears, travelling cranes, etc. shall be considered in the design of foundation of such structures. As a guide, the mass of the foundation should be at least 2.5 times the mass of the whole machine or as provided by the manufacturer/Vendor for dynamic analysis.

1.12 Vehicular Wheel Load

For any structure or pipeline below the roads, Class A loading of IRC 6 shall be considered.

1.13 Joints

Movement joints such as expansion joints, complete contraction joints, partial contraction joints and sliding joints shall be designed to suit the structure. However, contraction joints shall be provided at specified locations spaced not more than 7.5 m in both right angle directions for walls and rafts.

Expansion joints of suitable gap at suitable intervals of not more than 30 m shall be provided in walls, floors and roof slabs of liquid retaining structures.

Construction joints shall be provided at right angles to the general direction of the member. The locations of construction joints shall be decided on convenience of construction.

To avoid segregation of concrete in walls, vertical construction joints are normally provided at corners and junction of walls and in base slab. PVC water stops of 150mm width shall be used for walls and 230mm width for base slabs.

1.14 Design Criteria for Underground or Partly Underground Liquid Retaining Structures

Water level is assumed to be at the finished ground level (FGL) for design of all the structures. All underground, above ground or partly underground liquid containing structures shall be designed for the following conditions:

(i) Any structure in contact with water, submerged water or flowing water shall be designed in accordance with provisions made in IS3370.

(ii) Liquid depth up to full height of wall: no relief due to soil pressure from outside to be considered. Structure empty (i.e., empty of liquid, any material, etc.): full earth pressure and surcharge pressure wherever applicable, to be considered.

(iii) If water table exists, earth pressure to be considered for submerged soil conditions with reference to geotechnical recommendations, approved by the Engineer.

(iv) Partition wall between dry sump and wet sump: to be designed for full liquid depth up to full height of wall.

(v) Partition wall between two compartments: to be designed as one compartment empty and other full.

(vi) Structures shall be designed for uplift in empty conditions with the water table considered at FGL.

(vii) Walls shall be designed under operating conditions to resist earthquake forces from earth pressure mobilization and dynamic water loads (Hydrodynamic Impulsive Pressure).

(viii) For general retaining walls and large sized tanks where the walls are designed as retaining walls, sliding check shall also be performed along with overturning checks.

Overturning: The stability of a structure as a whole against overturning shall be ensured so that the restoring moment shall be not less than the sum of 1.2 times the maximum overturning moment due to the characteristic dead load and 1.4 times the maximum overturning moment due to the characteristic imposed loads. In cases where dead load provides the restoring moment, only 0.9 times the characteristic dead load shall be considered. Restoring moment due to imposed loads shall be ignored.

(ix) **Sliding:** The structure shall have a factor against sliding of not less than 1.4 under the most adverse combination of the applied characteristic forces. In this case only 0.9 times the characteristic dead load shall be taken into account as per IS codes.

(x) Underground or partially underground structures shall also be checked against stresses developed due to any combination of full and empty compartments with appropriate ground/uplift pressures from below to base slab. The stability of the structure should be checked against uplift using a factor of safety of 1.25 as per IS 3370(1). The individual members shall be designed for stresses due to uplift forces.

(xi) All the liquid retaining structures shall be designed for maximum design crack widths of 0.1mm for direct tension and flexure.

(xii) In case of Large and Deep Underground Tanks, the analysis can be carried by Finite Element Method using STAADPro or any other equivalent software commonly used and accepted in the industry.

1.15 Foundations

(i) The minimum depth of foundations for all structures, equipment, buildings, and frame foundations and load-bearing walls shall be as per IS 1904, but in any case, this shall not be less than 1.0 meter in the original soil.

(ii) Maximum safe bearing capacity and pile capacity of soil strata shall be taken as determined by the Bidder through his own independent investigations.

(iii) The Bidder shall ensure the technical feasibility of the offer submitted after visiting the sites and conducting independent investigations. The bidder must clearly understand that as the contract is Design, Build and Operate, the contractor shall be required to design and execute every such item(s) of work(s) which are considered required or necessary for the satisfactory completion and functioning of the entire work, commissioning of electro-mechanical equipment, Instrumentation, SCADA systems, trial run and operation and maintenance, and any other items required but not specified in the bid document, but are essential to complete the scheme. Nothing extra or additional shall be paid to the contractor on account of his failure to understand.

(iv) Care shall be taken to avoid the foundations of adjacent buildings or structure foundations, either existing or not, within the scope of this Contract. Suitable adjustments in depth, location, and size may need to be made depending on site conditions. The Employer shall accept no extra claims for such adjustments.

(v) Special attention is drawn to the danger of uplift being caused by the groundwater table. All underground structural slabs shall be designed for uplift forces due to groundwater pressure.

(vi) EGL (Existing Ground Level) and FGL (Finished Ground Level) shall be marked on all drawings showing foundation/sub-structure details and related design documents.

(vii) Machine/static equipment foundations shall be separated from adjoining parts of buildings, other foundations and floor/pavement slabs. Joints at floor/pavement slabs shall be suitably sealed.

(viii) Foundations and structures for machines subject to vibrations shall be proportioned so that the amplitude and frequency of the foundation/structure are within the permissible limits as per relevant BIS codes (or as required by the machine vendor).

(ix) Machine foundations shall be designed and detailed as per IS: 2974. All appendages to such foundations shall be reinforced suitably to ensure integral action.

(x) Pile Foundations - Design, Testing and Execution of piles shall be considered as per the provisions of relevant codes (conforming to latest version of IS: 2911), and in compliance with the Geotechnical report recommendations as applicable.

1.16 Design Requirements

The following are the design requirements for all reinforced or plain concrete structures:

a) All blinding and levelling concrete shall be a minimum 100 mm thick in concrete grade M10.

b) Cement used shall be BIS certified. Sulphate resistant cement shall be used for all liquid retaining structures and shall confirm to IS: 12330.

c) All liquid retaining reinforced concrete structures, concrete shall be of a minimum M30 grade and buildings, shall be of a minimum M25 grade (Footings, Plinth Beams, Columns, Slab and beams, etc., i.e., which are other than liquid retaining structures). Further, if there are any liquid retaining RCC tanks coming up with in the buildings, concrete shall be of minimum M30 grade for such RCC tanks also.

d) The reinforced concrete for liquid retaining structures shall have a minimum cement content of 400 kg/m^3 for M30 grade concrete and building structures shall have minimum cement content of 360 kg/m^3 with M25 grade concrete. Reinforced concrete shall have maximum slump of 100 mm and maximum water cement ratio of 0.48.

e) The minimum clear cover to all reinforcement including stirrups and links shall be 60 mm for all liquid retaining structures except for Launders/Gutter Slabs cover shall be 45mm. As the design consideration to control crack, though general requirements of IS 3370 shall be followed, permissible crack width shall be limited to 0.1 mm for liquid retaining structures.

f) The minimum amount of reinforcement in each of the two directions at right angles within each surface zone should be as per clause 8.1 of IS 3370 (Part 2):2021. The definition of surface zones is clearly shown in Figures 1 and 2 of IS 3370 (Part 2): 2021. For slabs, minimum of 10 mm dia bars shall be used to avoid any deformation of lesser diameter bars under loads prior to construction. Any liquid retaining structures which are more than 165mm thickness shall have reinforcement on both the faces.

g) The minimum cover to the main reinforcing bars for different members

1. Non–liquid retaining structures shall be as follows unless stated otherwise:

Slab (Floor, Roof, Canopy, and Staircase)	30 mm
Dome/Shell roof for Filter house/Clarifiers	25 mm
Beams (Sides, Bottom & Top)	40 mm
Lintels (all around)	30 mm
Columns	50 mm
Pedestals (in contact with earth)	50 mm
Basement wall, Retaining walls	
i) Face in contact with earth	50 mm
ii) Interior face	40 mm
Foundations	50 mm

2. Liquid retaining structures shall be as follows unless stated otherwise:

Walls – Face in contact with earth	60 mm
Walls – Face in contact with water	60 mm
Base slab in contact with water	60 mm
Base slab in contact with soil	60 mm
Launders/Gutter slabs	45 mm
Roof slab	45 mm
Machinehole	50 mm

h) For reinforced concrete structures, reinforcement shall be HYSD-CRS (Corrosion Resistant Steel) of Grade Fe 500. All physical and chemical properties of this Fe 500 grade steel shall confirm to IS: 1786-2008. Welded wire fabric shall conform to IS: 1566 as shown or specified in the drawing. The CRS (corrosion resistant steel) index shall be at least 1.35 when tested for Salt Spray test as per "ASTM B 117 – 2009 test procedure for 120 hours when compared with the Fe 500 normal reinforcement bars and with same bar diameter. All test results (including physical and chemical properties and salt spray tests) have to be produced for the respective bar diameter for each consignment of steel delivered at site and at a frequency of every 20 Metric Tons.

i) Reinforcement bars and structural steel to be procured only from Primary steel producers/Integrated Steel Plants such as SAIL/RINL/JSW/SHYAM STEEL/TATA STEEL using iron ore as the basic raw material and having in-house iron making facilities followed by production of liquid steel and crude steel with in-house rolling, adopting BF-BOF route or DRI-EAF technology as per Ministry of Steel guidelines. No Re-rolled material/secondary steel shall be accepted or allowed for any structural works. The steel and cement manufacturing company should have the latest ISO accreditation for Quality Management System.

j) All buildings shall have a minimum 1 meter wide, minimum 100 mm thick plinth protection paving in M15 grade concrete. Plinth protection shall be supported on well compacted strata of soling about 150mm/ plain cement concrete as required.

k) All pipes and ducts laid below the structural plinth and road works shall be surrounded with concrete of grade M15 having minimum 150 mm thick concrete or D/4 (D = outer dia. of pipe) thickness whichever is more.

l) Use of pressure relief valves to reduce uplift pressure due to ground water table shall not be allowed.

m) Detailing of the reinforcement shall be considered as per latest Indian code of practices and special publications as applicable.

n) Any structure or pipeline crossing below roads shall be designed for Class A of IRC loading.

o) Sliding layer or slip layer shall be provided between sub base and structural slab (Raft). Polythene sheets of 500 microns shall be provided as sliding layer as per IS specification.

p) Water tightness testing of liquid retaining structures shall be done in accordance with IS: 3370, (Part I) - 2021. It is described in Clause 1.31 of this document. The depth of water for testing shall be as per design depth.

q) A layer of 450mm thick rubble packing with approved stone, set in regular lines, hand-packed, filling the interstices with approved small stone chips and sand, consolidating by ramming or compacting with heavy roller after watering including spreading of 12mm layer of stone grit on top shall be carried out for all building works below grade slabs/rafts/footings under water logged conditions/high water table conditions.

The following minimum thicknesses shall be used for different reinforced concrete members, irrespective of design thicknesses:

(i) Walls for liquid retaining structures : 250 mm

(ii)	Roof slabs for liquid retaining structures (Other than flat slabs)	:	200 mm
(iii)	Bottom slabs/Raft for liquid retaining structures	:	300 mm
(iv)	Floor slabs including roof slabs, walkways, canopy slabs	:	125 mm
(v)	Walls of cables / pipe trenches, underground pits etc.	:	200 mm
(vi)	Column footings	:	300 mm
(vii)	Parapets	:	100 mm
(viii)	Precast trench cover, Chajja and all fascias	:	100 mm
(ix)	Column Dimension		
	a) Exceptional case (Based on any specific requirement)		
	i) To match with width of block masonry wall	:	200mm
	ii) To match with width of brick masonry wall	:	230mm
	b) In general case	:	300mm
(x)	Beam (To match with width of block masonry wall)	:	200mm
(xi)	Launder Base Slab/Baffle walls	:	200 mm
(xii)	Launder Vertical Wall, Baffle Wall, Gutter Slab	:	175 mm
(xiii)	Grade Slabs	:	200 mm

1.17 Materials in General

The term "materials" shall mean all materials, goods and articles of every kind whether raw, processed or manufactured and equipment and plant of every kind to be supplied by the Contractor for incorporation in the Works.

Except as may be otherwise specified for particular parts of the works the provision of clauses in "Materials and Workmanship" shall apply to materials and workmanship for any part of the works.

All materials shall be new and of the kinds and qualities described in the Contract and shall be at least equal to approved samples.

As soon as practicable after receiving the order to commence the Works, the Contractor shall inform to the Engineer of the names of the suppliers from whom he proposes to obtain any materials but he shall not place any order without the approval of the Engineer which may be withheld until samples have been submitted and satisfactorily tested. The Contractor shall thereafter keep the Engineer informed of orders for and delivery dates of all materials.

Materials shall be transported, handled and stored in such a manner as to prevent deterioration, damage or contamination failing which such damaged materials shall be rejected and shall not be used on any part of the Works under this contract.

1.18 Samples and Tests of Materials

The Contractor shall submit samples of such materials as may be required by the Engineer and shall carry out the specified tests directed by the Engineer at a NABL approved testing facility. Prior approval shall be obtained for testing the materials at a third-party laboratory/Engineering college as approved by the Engineer before starting the civil works.

Samples shall be submitted and tests carried out sufficiently early to enable further samples to be submitted and tested if required by the Engineer.

The Contractor shall give the Engineer seven days' notice in writing of the date on which any of the materials shall be ready for testing or inspection at the supplier's premises or at a laboratory approved by the Engineer. The Engineer shall attend the test at the appointed place within seven days of the said date on which the materials are expected to be ready for testing or inspection according to the Contractor, failing which the test may proceed in his absence unless instructed by the Engineer to carry out such a test on a mutually agreed date in his presence. The Contractor shall in any case submit to Engineer within seven days of every test such number of certified copies (not exceeding six) of the test results as the Engineer may require.

Approval by the Engineer as to the placing of orders for materials or as to samples or tests shall not prejudice any of the Engineer's powers under the Contract.

The provisions of this clause shall also apply to materials supplied under any nominated sub-contract.

1.19 Standards

Materials and workmanship shall comply with the relevant Indian Standards (with amendments) current on the date of submission of the tender.

Where the relevant standard provides for the furnishing of a certificate to the Engineer, at his request, stating that the materials supplied comply in all respects with the standard, the Contractor shall obtain the certificate and forward it to the Engineer.

The specifications, standards and codes listed below are considered to be part of this specification. All standards, specifications, codes of practices referred to herein shall be the latest editions including all applicable official amendments and revisions.

In case of discrepancy between the Specification and the Standards referred to herein, the Specification shall govern.

a) Materials

IS: 269 - Specification for ordinary Portland cement.
IS: 383 - Specification for coarse and fine aggregates from natural sources for concrete
IS: 428 - Specification for distemper, oil emulsion, colour as required
IS: 432 - Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement (Parts 1 & 2)
IS: 455 - Specification for Portland slag cement
IS: 458 - Specification for precast concrete pipes (with and without reinforcement)
IS: 650 - Specification for standard sand for testing of cement
IS: 651 - Specification for salt glazed stoneware pipes and fittings
IS: 777 - Specification for glazed earthenware tiles
IS: 808 - Specification for dimensions for hot rolled steel beam, column channel and angle sections
IS: 814 - Specification for covered electrodes for manual metal arc welding of Carbon and Carbon Manganese steel
IS: 1003 - Specification for timber panelled and glazed shutters (Parts 1 & 2)
IS: 1038 - Specification for steel doors, windows and ventilators
IS: 1077 - Specification for common burnt clay building bricks
IS: 1398 - Specification for packing paper, water proof, bitumen laminated
IS: 1489 - Specification for Portland pozzolana cement (Parts 1 & 2)
IS: 1566 - Specification for hard drawn steel wire fabric for concrete reinforcement

IS: 1580 - Specification for bituminous compounds for water proofing and caulking purposes
IS: 1786 - Specification for high strength deformed steel bars and wires for concrete reinforcement
IS: 1852 - Specification for rolling and cutting tolerances for hot rolled steel products
IS: 1948 - Specification for aluminium doors, windows and ventilators

IS: 1977 - Specification for structural steel (ordinary quality)
IS: 2062 - Specification for steel for general structural purposes
IS: 2140 - Specification for Stranded Galvanized Steel Wire for Fencing
IS: 2185 - Specification for concrete masonry units (Parts 1 & 2)
IS: 2202 - Specification for wooden flush door shutters (Parts 1 & 2)
IS: 2645 - Specification for integral cement water proofing compounds
IS: 2750 - Specification for steel scaffoldings
IS: 2835 - Specification for flat transparent sheet glass
IS: 3384 - Specification for bitumen primer for use in waterproofing and damp proofing
IS: 4021 - Specification for timber door, window and ventilator frames
IS: 4350 - Specification for concrete porous pipes for under drainage
IS: 4351 - Specification for steel door frames
IS: 4990 - Specification for plywood for concrete shuttering work
IS: 9862 - Ready mixed paint, brushing, bituminous, black, lead free, acid, alkali, water and chlorine resisting
IS: 10262 - Recommended guidelines for concrete mix design
IS: 12330 - Specification for sulphate resisting Portland cement
IS: 12709 - Glass fiber reinforced plastics (GRP) pipes, joints, and fittings for use for potable water supply
IS: 15931 - Specification for Solid Panel Foam UPVC Door shutters.
IS: 17953 - Specification for uPVC Profiles and Doors.

b) Tests

IS: 516 - Method of test for strength of concrete
IS: 1182 - Recommended practice for radiographic examination of fusion - welded butt joints in steel plates
IS: 1199 - Methods of sampling and analysis of concrete
IS: 2386 - Methods of test for aggregates for concrete (Parts 1 to 8)
IS: 2720 - Methods of test for soils (Parts 1 to 39)
IS: 2911 - Code of Practice for design and construction of Pile foundations (Part 4)
IS: 3025 - Methods for sampling and test (physical and chemical) for water and wastewater (Parts 1 to 59)
IS: 3495 - Method of test for burnt clay building bricks (Parts 1 to 4)
IS: 3613 - Acceptance tests for wire flux combination for submerged arc welding
IS: 4020 - Methods of tests for wooden flush doors shutters: Type tests
IS: 4031 - Methods of physical tests for hydraulic cement (Parts 1 to 15)
IS: 5807 - Method of test for clear finishes for wooden furniture (Parts 1 to 6)
IS: 7318 - Approval tests for welders when welding procedure approval is not required (Parts 1 and 2)
IS: 13311 - Methods of Non-destructive testing of Concrete: Part 1 & Part 2

c) Codes of Practice

IS: 456 - Code of practice for plain and reinforced concrete

IS: 783 - Code of practice for laying of concrete pipes
IS: 800 - Code of practice for general construction in steel
IS: 806 - Code of practice for use of steel tubes in general building construction
IS: 816 - Code of practice for use of metal arc welding for general construction in mild steel
IS: 817 - Code of practice for training and testing of metal arc welders
IS: 875 - Code of practice for design loads (other than earthquake) for building structures (Parts 1 to 5)
IS: 1081 - Code of practice for fixing and glazing of metal (steel and aluminium) doors, windows and ventilators
IS: 1172 - Code of practice for basic requirements for water supply, drainage and sanitation
IS: 1477 - Code of practice for painting of ferrous metals in buildings (Parts 1 & 2)
IS: 1597 - Code of practice for construction of stone masonry (Parts 1 & 2)
IS: 1742 - Code of practice for building drainage
IS: 1893 - Criteria for earthquake resistant design of structures (Part 1)
IS: 1904 - Code of Practice for Design and Construction of Foundation in Soils :General Requirements.
IS: 1948 - Specification of aluminium doors, windows and ventilators
IS: 2065 - Code of practice for water supply in buildings
IS: 2204 - Code of practice for construction of reinforced concrete shell roof
IS: 2210 - Code for design of reinforced concrete shell structures and folded plates
IS: 2212 - Code of practice for brickwork
IS: 2338 - Code of practice for finishing of wood and wood based materials (Parts 1 & 2)
IS: 2394 - Code of practice for application of lime plaster finish
IS: 2395 - Code of practice for painting, concrete, masonry and plaster surfaces (Parts 1 & 2)
IS: 2470 - Code of practice for installation of septic tanks (Parts 1 & 2)
IS: 2502 - Code of practice for bending and fixing of bars for concrete reinforcement
IS: 2571 - Code of practice for laying in-situ cement concrete flooring
IS: 2595 - Code of practice for radiographic testing
IS: 2751 - Recommended practice for welding of mild steel plain and deformed bars for reinforced construction
IS: 2911 - Code of Practice for design and construction of Pile foundations
IS: 2974 - Code of practice for design and construction of machine foundations (Parts 1 to 4)
IS: 3114 - Code of practice for laying of Cast Iron pipes
IS: 3370 - Code of practice for concrete structures for the storage of liquids (Parts 1 to 4)
IS: 3414 - Code of practice for design and installation of joints in buildings
IS: 3558 - Code of practice for use of immersion vibrators for consolidating concrete
IS: 3658 - Code of practice for liquid penetrate flaw detection
IS: 3935 - Code of practice for composite construction
IS: 4000 - Code of practice for High strength bolts in steel structures
IS: 4014 - Code of practice for steel tubular scaffolding (Parts 1 & 2)
IS: 4111 - Code of practice for ancillary structures in sewerage system (Parts 1 to 4)
IS: 4127 - Code of practice for laying of glazed stoneware pipes
IS: 4326 - Code of practice for Earthquake Resistant Design and Construction of Buildings
IS: 4353 - Recommendations for submerged arc welding of mild steel and low alloy steels
IS: 5329 - Code of practice for sanitary pipe work above ground for buildings
IS: 5334 - Code of practice for magnetic particle flaw detection of welds
IS: 5822 - Code of practice for laying of welded steel pipes for water supply

IS: 7215 - Tolerances for fabrication of steel structures
IS: 9595 - Recommendations for metal arc welding of carbon and carbon manganese steels
IS:10005 - SI units and recommendations for the use of their multiples and of certain other units
SP: 16 - Design Aids for Reinforced Concrete to IS 456
SP: 34 - Handbook on Concrete Reinforcement and Detailing
SP: 38 - Handbook of Typified Design of Structures with Steel Roof Trusses

d) Construction Safety

IS: 3696 - Safety code for scaffolds and ladder (Parts 1 & 2)
IS: 3764 - Safety code for Excavation work
IS: 7205 - Safety code for erection of structural steel work

1.20 General Arrangement of Plant

The following general guidelines shall be followed in the preparation of general arrangement of Plant:

- Sufficient room shall be allowed between components of plant and adjacent plant or fixed structures to permit safe and convenient access for operation and maintenance.

- An area adjacent to all mechanical plant shall be provided as a maintenance lay-down area.

- Fixed runways, lifting eyes, or other means shall be provided to permit the removal of the plant that may be required to be removed during the course of its normal operational life for maintenance or any other purpose.

- Areas where leakage is likely to occur, whether in normal use or during maintenance, shall be provided with covered drainage channels which shall direct spillage either to a suitable plant drain or to a sump from where it can be pumped to a plant drain.

1.21 Orientation

The works shall be laid out within the confines of the site in order to interface to the existing infrastructure of roadways and inlet and outlet pipe work. Underground services requiring to be relocated in order to accommodate the proposed site layout shall, with the approval of the Engineer, be relocated by the Contractor.

1.22 Buildings and Structures

All building and structure works shall generally comply with the following Employer's Requirements unless otherwise specified elsewhere.

1. All building works shall be of reinforced concrete framework (Concrete Grade of M25 as a minimum).

2. All external walls shall be in solid cement concrete blocks of concrete grade M15 and shall be provided as per IS: 2185 (Latest Revision) and shall be 200 mm thick.

3. All internal partition walls shall be in solid concrete blocks of concrete grade M15 and shall be provided as per IS: 2185 (Latest Revision). All internal walls shall be 200mm thick except for toilets. Toilet partition walls shall be in 100 mm thick solid concrete block.

4. (a) Finishes to concrete liquid retaining structures shall be :

F1 - External surfaces, buried

F2 - External surfaces exposed and up to 300 mm below ground level

F2 - Internal surfaces

(b) Finishes to other concrete structures shall be :

F1 - Buried

F1 - Exposed, where plastering is specified

F2 - Exposed

The type of finishes is explained in "Standard Basic Specifications for Civil and Structural Works" in Chapter 4.

5. All internal masonry surfaces finish shall have 12 mm thick plain-faced cement plaster in cement mortar (1:4) with neat cement finish on top. Additionally, one coat of primer and two coats of approved quality and shade plastic emulsion paint shall be provided.

6. All external masonry surfaces and concrete surfaces with rough board finish shall have 20 mm thick sand faced cement plaster in two coats, base coat 12 mm thick in cement mortar 1:4 and finishing coat 8 mm thick in cement mortar 1:4. Waterproofing compound of approved make and quality shall be added to the cement mortar in proportions as specified by the manufacturer.

7. All external surfaces above ground level shall have one coat of primer and two coats of waterproof cement-based paint of approved quality and shade. A coat of silicone water-repellent paint shall also be applied thereto.

8. Toilet areas, walls, and ceilings shall have one coat of primer and two coats of plastic emulsion paint.

9. Toilet floor slab shall be filled with brick bat Coba (broken bricks in lime) and provided with waterproofing as per the specifications of an approved specialist waterproofing company.

10. The finished floor level in toilet areas shall be 25 mm below general finished floor level elsewhere in the building.

11. The flooring in operator's room, loading/unloading bay, MCC cum Panel room shall be in 25mm thick Kota stone slab of approved shade and pattern and placed over 20 mm thick base of cement mortar 1:4 to give overall thickness of 45 mm. Half tile skirting shall also be provided in these areas.

12. The flooring in the pumping stations, chlorination building, centrifuge building, workshop, blower room, chemical building, security room, D.G. Room, any other equipment room, etc.., shall be 60mm thick cement flooring with metallic concrete hardener topping, under layer of 42mm thick cement concrete 1:2:4 (1 cement : 2 coarse : 4 graded stone aggregate 16mm thick nominal size) and top layer of 18mm thick metallic concrete hardener consisting of mix 1:2 (1 cement : 2 stone aggregate 6mm nominal size) by volume & mixed with metallic hardening compound of approved quality @ 3 kg/m^2, including cement slurry and rounding off edges.

13. Toilet areas shall have 300 mm x 600 mm x 6 mm thick ceramic non-slippery tiles placed in cement mortar 1:4 to give an overall thickness of 50 mm. 2100 mm high dado, in 150 mm x

150 mm x 6 mm thick glazed tiles (approved make, shade and pattern) placed in cement mortar 1:3 shall also be provided in these areas.

14. The flooring along with skirting in administration building including PLC and SCADA Room shall be 20 mm thick mirror polished, machine cut granite slab of approved shade and pattern placed in cement mortar (1:4). 150mm high skirting shall be provided in these areas. 750mm wide granite stone shall be provided for laboratory platforms fixed over double sandwiched support as directed and the edges of granite is to be embedded into the wall.

15. The laboratory shall consist of cupboards/ almirahs/ cabinets made from suitable marine grade waterproof plywood. The floor tiles and dado shall be done with ceramic unglazed vitreous acid resistant tiles 300mm x 300mm size of approved quality.

16. The toilet facilities shall include at least:

(i) 2 Nos. Water closets with white porcelain Orissa pan minimum 580 mm long with flushing cistern of 10 liters capacity.

(ii) 2 Nos. Urinals of sizes 600 mm x 400 mm x 300 mm flat back type in white porcelain separated by a marble partition of size 680 mm x 300 mm.

(iii) 2 Nos. wash basins of size 510 mm x 400 mm in white porcelain with inlet, outlet and overflow arrangements.

(iv) 2 Nos. mirror of size 400 mm x 600 mm wall mounted type fitted over wash basins.

(v) 2 Nos. plastic liquid soap bottles.

(vi) 2 Nos. Stainless steel towel rails minimum 750 mm long.

(vii) All stopcocks, valves and pilar cocks shall be heavy duty chromium plated brass.

(viii) All fittings such as `P' or `S' traps, floor traps, pipes, down take pipes etc.

(ix) The sewage from toilet blocks shall be led to the wet well of the terminal sewage pumping station if present under this contract or to the closest gravity sewer or to septic tank with soak pit with necessary arrangements.

17. All staircases shall have granite non-skid tiles for treads and risers of approved make and shade and half tile skirting set in cement mortar in 1:4 to be provided. All concrete stairs shall have aluminium nosing over 2 mm thick rubber strip of width for the full length of the tread. Nosing shall be fixed with countersunk screws.

18. Stairways shall be provided to permit access between different levels within buildings. Staircase shall be minimum 1200mm wide, minimum Tread = 250 mm, maximum Riser = 175 mm and maximum 15 number of steps per flight unless specified otherwise. Staircases in general shall not be steeper than 40°. The maximum vertical run for a single flight of stairs shall be 3.0 M.

19. All roof tops and overhead tanks shall be made accessible with ladder provision. Vertical step ladders fitted with landing point extensions shall be permitted where considered appropriate by the Engineer to access areas not frequently visited. Steel staircases shall be constructed of standard channel stringers with M.S. grating treads 25mm thick with non-skid nosing. Steel

Ladders shall be minimum 600mm wide and shall not exceed 6m of straight and shall be painted with epoxy paint. PVC encapsulated Cast Iron rungs or step shall be provided on the inner side walls of all the liquid retaining structures at 300mm spacing.

20. All Hand railings shall be made up of Stainless Steel 304 confirming to ASTM A-240M. Height of railing not less than 1200 mm. Stainless steel handrails of 10S pipe for ramps, staircases, walkway, chambers and Channels etc. are made out of stainless steel hollow pipes, using 50mm dia. for verticals @ 900mm c/c are fixed to the ramps or steps by drilling with bolts and 100 mm dia. SS base plates 10 mm thick for fixing of vertical pipes 4 nos. anchor bolts & 40mm dia. pipes are fixed horizontally for 2 rows top one pipe are fixed with vertical pipes another one are fixed with elbows & 25mm dia. pipes are fixed horizontally for 2 rows with elbow top measure @ equal intervals including cutting, welding, bending wherever necessary with suitable caps @ tops, bottoms, corners finishing with mat/shining etc. Mechanical properties of stainless-steel Grade-304 shall be as follows:

	Tensile Strength (MPa) min	Yield Strength 0.2% proof (MPa) min	Elongation (% in 50 mm) min	Hard Ness	
				Rockwell B (HR B) Max	Brinell (HB) Max.
304	515	205	40	92	201

21. The reinforced concrete roofs shall be made waterproof by application of an approved waterproofing treatment with PU based single component elastomeric pure polyurethane / bitumen membrane/ brick bat Coba/ Yelahanka tiles. The finished roof surface shall have adequate slope to quickly drain the rainwater to rainwater down take inlet points.

22. All roof floors shall have minimum 750 mm height solid concrete block parapet wall where access is provided and shall have minimum 300 mm height solid concrete block parapet wall where access is not provided.

23. For roofing drainage, uPVC 6kg/sqm rainwater down takes with Bell mouth and uPVC grating at top shall be provided. For roof areas up to 40 sqm minimum two nos. 110 mm diameter down take pipes shall be provided. For every additional area of 40 sqm or part thereof, at least one no. 110 mm dia. down take pipe shall be provided.

24. Top surfaces of chajjas and canopies shall be made waterproof by providing a screed layer of adequate slope or application of an approved roof membrane and sloped to drain the rain water. All chajjas and canopies shall be provided with drip moulding.

25. Building plinth shall be minimum 500 mm above average finished ground level around building. Damp proof course shall be minimum 50 mm thick in cc 1:3:6.

26. All doors, windows, rolling shutters shall have lintels above. Chajja protection to lintels on external walls shall be such as to prevent the rain water splashing into the building. Chajja projection of minimum 750 mm for rolling shutters, 600 mm for doors and 600 mm for windows shall be provided to prevent the rain water splashing into the building. Chajja shall be projected 150 mm on either side from size of doors/windows/rolling shutters.

27. All windows and ventilators shall have 25 mm thick Bull nosed Granite stone sills bedded in cement mortar (1:3).

28. Solid panel foam upvc doors, windows and ventilators shall be used and confirm to IS 15931. The profiles used for panels shall confirm to IS 17953.

    a. 2-track x 2-panel sliding windows made out of multi-chambered UPVC (Matching to RAL-9016) sections and with minimum TiO2 (Titanium Dioxide) at 6PHR with TPE (Thermo Plastic Elastomer) and lead-free, gaskets -grey colour having isolated drainage and reinforced with Galvanized Iron profile throughout the window frame. The outer frame having a overall size of 60mm width x 45mm height with reinforcement of 1mm thickness and Sash with overall size of 39mm X 58mm with GI reinforcement of 1mm for the frame and 1.5 mm for the sash. Coextruded Glazing bead for fixing glass shall be of size 20mm x 24mm. Windows shall be provided with 5mm plain float glass, standard hardware & single point locking system with touch lock. Wall thickness of frame & sash shall be 2-2.5 mm.

    b. Openable doors made out of multi-chambered UPVC (Matching to RAL-9016) sections and with minimum TiO2(Titanium Dioxide) at 6PHR with TPV (Thermo Plastic Vulcanized) and lead-free with gaskets -grey colour having isolated drainage and reinforced with Galvanized Iron profile throughout the openable frame. The frame having overall size of 60mm x 55mm with GI reinforcement of 1mm thickness and openable sash with overall size of 60mm x 102mm and GI reinforcement of 2mm thickness. Coextruded Glazing bead for fixing glass shall be of size 20mm x 34 mm. Windows shall be provided with 6mm plain float glass, Standard hardware with 2D/3D hinge & Multi point locking system with Handle. Wall thickness of frame & sash shall be of 2mm-2.5mm.

29. Doors, Windows and Ventilators shall be of size as per schedule to be submitted by the Contractor for approval of Engineer. The minimum size shall be as per below:

    Door of opening size 1.2m x 2.1m
    Door of opening size 0.75m x 2.1m for toilets
    Glazed windows of minimum size 1.2m x 1.2m
    Ventilators of minimum size 0.6m x 0.6m

30. Openings of the windows & ventilators shall be minimum 25% of the external wall area.

31. Ventilator shall also be provided where height of floor is more than 3m.

32. Rolling shutters shall be made of 80 x 1.25 mm MS laths. Rolling shutter shall be of minimum size 3m wide x 3.0m high. Rolling shutter shall be provided in MCC cum panel room, chlorine tonner shed, and centrifuge at entry and exit of the pump house for access to pumps, motors, valves, panels, blowers and as wherever required. Up to 3m height mechanical operated rolling shutter shall be provided, and if the height is more than 3m, then an electrically operated rolling shutter shall be provided.

33. All structural steel members shall be painted with two coats of enamel paint over one shop and one field coat of red oxide zinc chrome primer. All concrete channels and ducts used for conveying liquid shall have inside finish of type F2. The width of concrete channels shall not be less than 500 mm. All open channels shall be provided with SS304 hand railings.

34. All exposed surfaces of inserts embedded in concrete shall be painted with two coats of enamel paint over one coat of Red Oxide Zinc Chrome Primer. Surface in contact with concrete shall not be painted.

35. Kerbs to be provided below the hand railing on the catwalks/pathways should be as per relevant sections of Factory Act. It shall not be less than 150mm.

36. All structures in the ISPS and Treatment plant units shall be provided with appropriate sign boards indicating the function of the units involved written in Kannada and English Languages.

37. Wherever equipment and machinery are to be moved for inspection, servicing, replacement etc., suitable movable gantry of minimum capacity of 2 tonnes or more as required shall be provided with monorail and operating equipment.

38. The design of buildings shall reflect the local climatic conditions. Process buildings shall, as far as possible, permit the entry of natural light, and the use of glazed panelling shall be kept to a minimum and preference given to wall openings protected by weather canopies.

39. Emergency exit doorways shall be provided in all buildings to comply with local and international regulations. Stairways and paved areas shall be provided at the exit points.

40. Toilet blocks in process buildings and control blocks shall be provided with a sink with two drinking water taps of 20 mm size with adequate inlet and outlet connections.

41. The side walls of buildings shall, except those used for storage and handling of Chlorine gas comprise at least 15% ventilated brickwork or louvers. Ventilated brickwork or louvers shall not be used where the ingress of driven rain could affect plant or stored materials. Flat roofed areas shall be provided with roof vents to encourage a through flow of air further.

42. All the walkways shall have a minimum 1.0 m width and shall be secured with handrails and toe guards.

43. Suitable River flow training systems/Flow diversion to be adopted at required locations/places in compliance with the relevant Geotechnical Investigation Report recommendations as applicable.

44. All concrete structures in contact with sewage and/or sludge shall be provided with full interior corrosion protection linings and/or coatings of appropriate material and thickness to be approved by the Employer. For Aeration Basins, interior lining shall extend from the top of the wall down to 1.0 meter below the lowest operating water level.

45. For structures containing water or process liquid, the top of the wall shall be at least 0.5m higher than the maximum water surface level calculated at high flood level and peak plant flow. The top level of internal plant roads and approaches shall be at least 150 mm above the Finished Ground Level. The difference between HFL and FGL shall be 1.0m.

46. If the High flood level is more than Ground Level, then road shall be constructed on the Earthen Embankments/Engineered Embankment. Earthen Embankments/ Engineered Embankment shall be constructed with side slope of at least 2 horizontal to 1 vertical. Stone pitching shall be provided on both sides of the embankment as per IS: 8237. Top width of embankment shall be taken as 6.0m. Top level of embankment shall be 1.0 m above high flood

level. The excavated earth from the plant can be used for earthen embankment construction if suitable, and if required, extra earth can be borrowed from the borrow pit as approved by the Engineer.

47. Anti-termite treatment, under and around the column pits, walls, trenches, basement excavation, top surface of the plinth filling, junction of wall and floor, along the external perimeter of building, expansion joints, over the top surface of consolidated earth on which apron is to be laid, surrounding of pipes & conduits, with chloropyriphos emulsifiable concentrates of 20% concentration is to be provided for this only plinth area of the building at ground floor only shall be measured.

48. Engineered Embankments for plant structures in swampy or waterlogged areas shall consider compliance with the relevant Geotechnical Investigation Report recommendations as applicable.

49. All requirements for Engineered Embankment and all other associated works connected to this system (i.e. all controlled filling requirements, type & suitability of materials, methodologies testing, protective system, aprons, proper slopes, stability, specifications, quality control, and all other requirements pertaining to this system of works, etc.,) shall be considered in compliance with relevant geotechnical investigation report recommendation as applicable. Also, to enlist the service of an experience and specialized agency for all related design aspect consideration, equipment specifications, and implementation methodology, etc., as an advice for the same.

50. Complete Disc Filter tank including its free board and its inlet & outlet channel shall be provided with White/Sky Blue porcelain - like finish (tiles) free from any pits or recesses to avoid accumulation of bacteria and dirt, else which might hinder to achieve desired outlet fecal coli-form as per KSPCB and NGT norms. The disk filter roof shall be provided with Gable roof shed. The roof shall be covered with Mangalore roof tiles.

51. Complete chlorine contact tank including its free board and its inlet & outlet channel and outfall structure shall be provided with White/Sky Blue porcelain - like finish (tiles) free from any pits or recesses to avoid accumulation of bacteria and dirt, else which might hinder to achieve desired outlet fecal coli-form as per KSPCB and NGT norms.

52. GI chain link fencing shall be 2.75 m high above finished ground level with top 0.75 metre of barbed wire confirming to IS 278. The fencing shall include fabric mesh confirming to IS 2721, top and bottom runner wires, vertical posts, GI strap at every vertical post, etc, all as approved by the Engineer.

53. All walkways shall be provided with 300x300mm ceramic glazed tiles of first quality conforming to IS : 15622, of approved make laid on 20 mm thick bed of cement mortar 1:4 (1 Cement : 4 Coarse sand), jointing with grey cement slurry @ 3.3 kg/ m2 including pointing the joints with white cement and matching pigments.

1.23 Roadways, Pathways & Hard standings

A comprehensive network of roadways with turning bays as required for access, removal of plant and equipment, removal of sludge, grit etc. From site shall be provided around the treatment plant to link in with the existing road network and permit access to the plant for necessary maintenance, delivery of consumables and personnel access.

All roads shall be designed and constructed as per the specifications and as per site requirements. Bidder shall provide minimum 3.5 m wide internal roads with 1.50m shoulder on one side, which shall be utilised for future expansion of the internal road and 5.0 m wide approach road shall be provided until WwTP Entry gate from the nearby Main Road or Highway. 1.5 m shoulder on both sides of the road shall be provided as per site requirement and as directed.

The road works shall be designed and constructed as per MORTH guidelines and specifications. The minimum road layers shall consist of granular sub base, sub grade, wet mix macadam (2 layers with compacted thickness of 150 mm), semi dense bituminous concrete, bituminous macadam and Bituminous concrete as per the design requirements All roads shall be provided with drainage and shall be constructed to prevent standing water.

Paved pedestrian access ways shall be constructed to provide a network of logical routes interlinking plant areas. Damage to any existing roads resulting from the Contractor's use shall be made good to the Engineer's satisfaction.

Hard standing areas with shading facility shall be provided to permit the parking of vehicles involved in the delivery of consumables from blocking site roadways during unloading or loading. The road system shall be designed such that vehicles involved in the delivery of consumables can follow a continuous route through the works and out again without the need to reverse or carry out complicated manoeuvres in order to exit the site.

1.24 Site Drainage

The Contractor shall provide a site drainage system. The system shall comprise of the following:

- Storm Water Drainage
- Foul Drainage
- Process Drainage

1.24.1 Storm Water Drainage

The major storm water drains passing by or within the WWTP complex shall be designed as per CPHEEO requirements, considering the contributing catchment area. Necessary cross drainage works shall be provided for road crossing etc. If the existing storm water drain is passing through the center of the WwTP area, the storm water drainage alignment shall be diverted along the edge of the WwTP complex area for proper usage of the WwTP area.

For the internal storm water drains adjacent to the existing and proposed roads (under the contract) shall be sized for a rainfall intensity of 50 mm/hr, allowing for 100% run off. The drains adjacent to roads for walls and floor shall be in RCC M 20 grade. The floor is to be laid over a minimum thickness of 10 cm thick 1:3:6 PCC bed and the drain is to be covered with M 25 grade RCC slab. The minimum width of the drain shall be 300 mm. The storm water drainage system shall also be designed to cater to the runoff from the existing plot areas and structures, if necessary, depending upon the site topography.

1.24.2 Foul Drainage

The foul drainage system shall accept discharge from toilets, washrooms, offices and the laboratory. The foul drainage system shall discharge to a septic tank of appropriate volume or shall be led to the wet well of the terminal sewage pumping station.

1.25 Flood Protection Works

An Earthen Embankment with minimum slope of at least 2 horizontal to 1 vertical on both sides has to be constructed as required. Slope of the embankment shall be decided as per the soil properties. Stone pitching shall be provided on the both the sides of the embankment as per IS: 8237. Top width of the embankment shall be at least 3.5m. Embankment shall be designed as per IS: 12094.

Earth for the embankment & site grading shall be made available from the contract package of the same project. Excavated earth from all Units of WwTP and pumping station proposed to be constructed as per the contract shall be used for the construction of earthen embankment and site grading. If required, excavated earth from treatment plant shall also be used for earthen embankment and site grading. The embankment shall be constructed with the available material as per the standard specification.

GI chain link fencing shall be 2.75 m high above finished ground level with top 0.75 metre of barbed wire confirming to IS 278. The fencing shall include fabric mesh confirming to IS 2721, top and bottom runner wires, vertical posts, GI strap at every vertical post, etc, all as approved by the Engineer.

1.26 Cable and Pipe work Trenches

Cable and pipe work trenches shall generally be constructed in reinforced concrete.

Trenches within the buildings or Plant areas shall be covered with M20 precast R.C.C covers. The trenches shall be suitably sloped to drain rain water. All uncovered openings shall be protected with hand railing

Layout of trenches outside the buildings shall allow space for construction of future trenches where necessary with due consideration for planning for future developments. This aspect shall be brought to the notice of the Engineer while planning the works.

1.27 Pipes and Ducts

R.C.C ducts for drainage shall have minimum 1 meter over precast cover (M20 concrete, Heavy duty) while laid under roads. Access shafts of size not less than 600 mm x 1000 mm shall be provided.

All drains (except storm water drains adjacent to roads) shall be covered with precast RCC slab and designed structurally for appropriate loads.

1.28 Precast Compound Wall and Gate

Compound wall shall consist of RC precast slab panels (M25) with minimum 60m thickness BWSSB logo written in both Kannada and English Languages RC post at regular intervals including plinth beam as supports for the panels and necessary RC foundation system for the same along with barbed wire stretched between MS angles fixing at the top of the precast panels with necessary fixtures etc.,

All structural designs and Specifications shall confirm to relevant codal provisions.

An Indicative Typical Boundary wall profile of TYPE-I & TYPE-II is enclosed as reference for the same. (Refer to Sketch -1, appended in Page 32 & 33)

Each proposed ISPS and Sewage Treatment plant shall have one main gate to access the plant irrespective of existing gate at the premises of existing plant site. Minimum clear width of main gate shall be 6m. Main gate shall have 1.5m wide wicket gate. Gates shall have as external framework of GI pipes and internal framework of MS flats. Gate shall be fixed on RCC columns. The design and pattern of gate with drawing shall be submitted for approval of the Engineer. The gate shall have all necessary hinges, locking arrangement, rolling arrangement and painting complete, as approved by the Engineer.

1.29 Retaining wall

1. Retaining wall shall be RCC with minimum M25 grade of concrete. Wall foundation shall be placed on virgin soil and not on backfill soil. Foundation shall extend to a depth of at least 1.0 meter below finished ground level or as required. The top of wall shall be 0.50m above the FGL.

2. Expansion joints shall be provided in the retaining wall.

3. In retaining walls, 100mm dia weep holes shall be provided at 1m vertically and horizontally. The lowest weep hole shall be about 30cm above the ground level. All weep holes shall be surrounded by loose stones and shall have sufficient fall to drain out the water quickly.

1.30 Landscaping

The site shall be landscaped once the Works are substantially complete. Landscaping area shall be marked in layout plan.

Landscaping shall include planting of suitable trees and development of grassed areas. Landscaping in general shall meet ecological and environmental conditions of the site. Road widths shall determine the size of the tree height and spread to be selected for planting. Trees suitable for local conditions shall be selected. Medicinal and fruit trees shall be avoided. Landscaping shall be maintained in good condition till the completion of contract. Area for landscaping shall be equal to total area of project site minus area for the ISPS/Treatment plant units and the area required for roads, sidewalks and drains.

1.30.1. Tree Planting

Pits dug a few days in advance of actual planting shall be allowed to weather and be filled with top soil mixed with manure. Size of the pit shall be as per standard requirement. Only one tree shall be planted in each pit. A guard made of bamboo with wire mesh or bricks or M.S. rings as approved by Engineer shall be provided. A minimum of 100 trees shall be planted in each WwTP layout or any other suitable location shown by Engineer. A minimum of 20 trees shall be planted in each ISPS site layout or any other suitable location shown by Engineer. All trees shall be maintained upto the end of O & M period.

1.31 Hydraulic Testing of Liquid Retaining Structure

In addition to the structural test of structures as applicable, the liquid retaining structures shall also be tested for water tightness test at full supply level as described in clauses 12.1,12.1.1, 12.1.2 and 12.1.3 of latest version of IS 3370 (Part I).

On completion of the structure and before its commissioning, the contractor shall carry out a water tightness test for the maximum water head condition i.e. with the water standing at Full Supply Level (FSL) of the structure. This test shall be carried out preferably in dry season in accordance with the procedure given below:

The water tightness test shall be carried out when the construction of liquid retaining structure is completed and when it is possible to fill the structure and ensure that uniform settlement of the structure as a whole or as directed by the Engineer. Before the filling operations are started the structure shall be inspected by the Engineer and the Contractor's Representative and the condition of surfaces of walls, contraction joints shall be noted and it shall be ensured that the jointing material filled in the joint is in position and all openings are closed. The Contractor shall make necessary arrangement for ventilation and lighting of the structure by way of floodlights, circulators etc. for carrying out proper inspection of the surfaces and inner conditions if so desired by the Employer. Records of leakages starting at different levels of water in the reservoir, if any, shall be kept.

The liquid retaining structure once filled shall be allowed to remain so for a period of seven days before any readings of drop in water level are recorded. The level of the water shall be recorded against the subsequent intervals of 24 hours over a period of seven days. The total drop in surface level over a period of seven days shall be taken as an indication of the water tightness of the structure, which for all practical purposes shall not exceed 20 mm excluding evaporation loss. Also there shall be no indications of the leakages around the opening or on the walls.

If the structure does not satisfy the condition of test and the daily drop in water level is decreasing, the period of test may be extended for a further period of seven days and if the specified limit is then reached the structure may be considered as satisfactory.

The external faces of structure shall not show any signs of leakage and shall remain apparently dry over the period of observation of seven days after allowing a seven day period for absorption after filling.

In case the drop in level exceeds the permissible level limit and signs of leakage with the stipulated period of test, the Contractor shall carry out such additional works and adopt such measures as may be directed by the Engineer to reduce the leakage within the permissible limits. The entire rectification work that shall be carried out in this connection shall be at the Contractor's cost. Contractor shall have to make arrangement for filling emptying the structure at his own cost.

If the test results are unsatisfactory, the Contractor shall ascertain the cause and make all necessary repairs and repeat the liquid retaining structures test procedures, at his own cost. Should the re-test results still be unsatisfactory after the repairs, the structure shall be condemned and the Contractor shall dismantle and reconstruct the structure, to the original specification, at his own cost.

During testing and during defect liability period the impression marks created due to seepage shall be rectified and made good.

No separate payment shall be made for water tightness test and the cost thereof shall deem to be covered in the rates quoted for the works.

1.32 Non-Destructive Testing of RCC Structures

Non-Destructive Testing (NDT) shall be carried out as per the latest IS: 13311 codes as per the instruction given by Employer.

Commonly used NDT to find quality, structural integrity and soundness of in situ concrete are:

1. Rebound Hammer Test is a qualitative field test method to measure surface hardness of concrete to find insitu concrete strength.

2. Ultrasonic Pulse Velocity (UPV) Test is a qualitative field test method for determination of discontinuities, cracks and depth of cracks of concrete.

3. Core cutting/Sampling Test is a field cum lab test for assessment of strength, density, texture and permeability of concrete.

4. Radiography Test for taking photographs showing details inside of concrete member, where other NDT methods are not suitable.

5. Impact Echo Test is a field/laboratory test method to detect hidden damage and its extent.

In case there is any distress in concrete during the execution, Engineer can take decision to go for NDT on the RCC construction before taking any action. Contractor shall conduct NDT tests at his own cost.

1.33 Specification for Anti-Corrosive Internal Coating/Lining protection of Concrete Surfaces

Application limits of Anti-Corrosion Internal Coating/Lining for Concrete Surfaces:

1. All units upstream of secondary treatment units shall have to be provided with internal coating/lining for the full internal surface area (Walls and base slab).

2. For the units - Anaerobic Zone, Anoxic Zones, Aeration Zones and Aeration Basin Effluent Channels, internal coating/lining shall be provided on the walls only from the top of the structure to 1.0 m below the lowest operating liquid level.

3. For the units handling the solids part such as Sludge Thickener, and all other units, internal lining shall to be provided for the entire internal surface area.

Contractor shall adopt any one of the following materials for internal coating/lining, which should be grey coloured, solvent-free, machine sprayed, resistant to water and chemicals, have a good bond between the concrete surface and lining/coating material, and submit their methodology for approval by the Engineer. No signs of swelling, scratches, or peeling of the coating specimen shall be observed after application of the coating or lining.

Concrete Structure- Surfaces must be clean, dry and free from curing compounds, laitance, releasing compounds, oil, grease, dirt, chalk, or previously applied coatings. Laitance must, therefore, be removed by sweep blasting or other means prior to coatings application. Ensure that the concrete is sufficiently dry to receive coatings; use a moisture meter. The 6% maximum moisture content shall be permissible. a minimum surface thickness of 500 microns is recommended.

Steel Structures- All surfaces to be coated must be clean and free from dust, grease, oil or loose material. a minimum surface profile of 50- 75 microns is recommended.

Below are some of the vendor products accepted. However, the process and application requirements shall be matched and approved by the engineer in charge before the start of work for the products and

vendors mentioned below. Also, if any new material and vendor meets the process requirements, as stated above, the Engineer in charge shall approve the material specifications of the manufacturer.

Sl No	Approved Vendor	Approved/Appropriate product
1	Sika India Pvt. Ltd.	Intertol Poxitor
2	STP Limited	Shalipoxy – CTE 406
3	BASF Construction chemicals	MasterSeal – 7000CR
4	Fosroc	Nitocote NT402
5	International - PC	Interzone 954

1.34 Rain Water Harvesting System

The Rain water harvesting for the proposed WwTP & ISPS complex shall be carried out in line with the regulatory guidelines specified by Bangalore Water Supply and Sewerage Board (BWSSB) & GOK norms.

1.34.1 Components of the Rain water Harvesting scheme

1. Rainwater harvesting carried out for enriching the groundwater resources essentially consist
    a) Common collection tank and
    b) Pipeline(s)

2. Following are the main components proposed for the roof water harvesting system at the WwTP including their location in the project area:
    a) Rainwater pipes from the roofs of all the building.
    b) First flush piping system.
    c) Storm water drains adjoining the roads of the plant.

1.34.2 Rainwater harvesting system for buildings

The run off from the roof top of all buildings shall be collected in the common collection area/Rain water harvesting pits provided at suitable locations in the plan area with in the plant and shall be allowed to percolate.

1.34.3 Rainwater harvesting system for plant area

The runoff from internal road side drain and major plant are shall be drained to rainwater harvesting structures for ground water recharge.

1.35 Well Sinking

The Well Sinking shall be proposed for Wet wells, where the surrounding area is in water logged condition or water table is up to FGL and it is difficult for open foundations. Well Sinking shall be done as per specifications mentioned in Part-10 and shall meet the requirements as mentioned in Part-1.

1.36 Gabion

1.36.1 General

A Gabion is a wire cage that can be stacked vertically in a wall and then packed with rough stones and normally used as retaining walls. The Gabions protect slopes and stream banks from the erosive forces of moving water. This bund should keep the construction area dry and free from flood waters. It should be envisaged to provide firm bank protection, for the construction of WwTP/ISPS. The requirement of Gabion wall is mentioned in Part-1, additional scope details for civil works under works-A.

1.36.2 Specification

Gabions are compartmented rectangular containers made of heavily galvanised steel wire, filled with stones, the gabion becomes a large, flexible and permeable building block. Gabions comprises of welded wire mesh panels accurately cut to size with heavy section wire spirals used for interconnecting the edges. The meshes and spirals are pre-galvanized with zinc coating of 450 gram per sqm. Gabion shall be confirming to ASTM-A974 (Standard Specifications for Welded Wire Fabric Gabions and Gabion Mattresses).

Gabion shall be provided up to site FGL. Top width of gabion at FGL shall be minimum 1.0m the bottom of the gabion shall be projected minimum 1.0 m below the natural Ground level with 300mm rubble soling below the base as a levelling course. The boulders used in gabion shall be hard and shall not deteriorate under water. The sections shall be worked out considering 10% porosity with a depth of 1m below the ground to the top level and boulder size shall not exceed 200mm.

Stability of the gabion wall under static condition and possible seismic loading shall be ensured for its long-term performance and Stability analysis shall be carried out in accordance with IRC -89 and relevant codes.

1.36.3 Laying Wire Crates and Mattresses

Wire crates shall be made from PVC coated hot dipped galvanized mild steel wire of diameter not less than 4 mm in annealed condition having tensile strength of 300-450 MPa conforming to IS: 280. The galvanizing coating shall be heavy coating for soft condition conforming to IS: 4826. Further for design purposes the contractor shall take into account the requirements of the following BIS codes also –

IS 16013~Welded Wire Gabions (metallic-coated or metallic-coated with PVC coating).IS 16014~Mechanically woven, double -twisted, hexagonal Wire Mesh Gabions, Rivet Mattresses and Rock fall Netting (Galvanized steel wire or Galvanized steel wore with PVC coating)

The mesh of the crate shall not be more than 150 mm. Where these have to be deposited and there is a chance of overturning, the crate shall be divided into 1.5 m compartments by cross netting.

For deep or inaccessible situations, wire crates can be made smaller subject to the approval of the Engineer. Wire crates built in-situ, shall not be larger than 7.5 m x 3 m x 0.6 m nor smaller than 2 m x 1 m x 0.3 m. Sides of large crates shall be securely stayed at intervals of not more than 1 .50 m to prevent bulging. The Contractor shall design and submit all designs, drawings, method statements, material submittals, Quality Assurance Plans required for the construction of the Gabion structures to the Engineer-in-Charge.

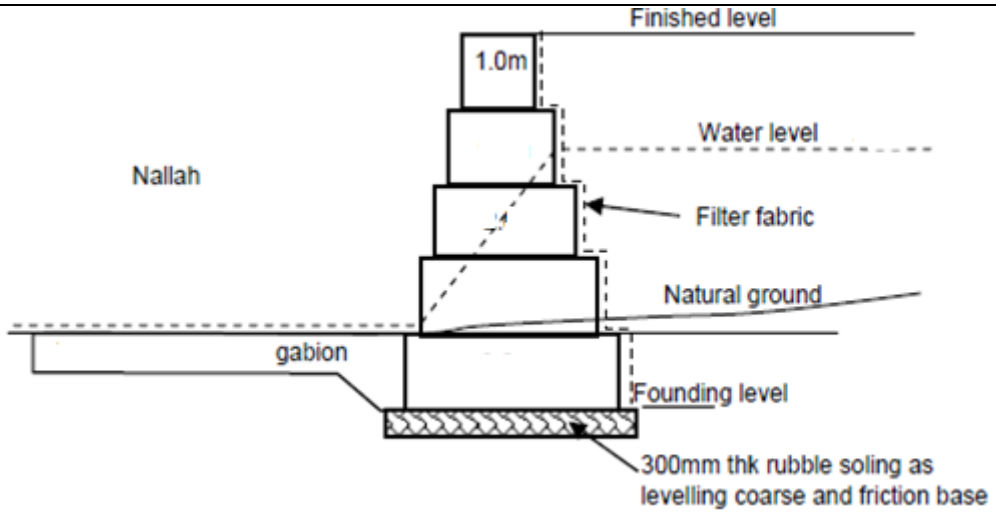


Figure: TYPICAL SECTION OF GABION WALL

1.37 Pile Foundations

1.37.1 General

The design of Pile foundation shall be in accordance with IS: 2911- Bored cast in-situ piles with minimum grade of M30. Where it is anticipated to fill the low-lying WwTP/ISPS areas to a depth of 2m to 5m (Engineered fill), waterlogged areas, soft soils, and low SBC areas, it is practically difficult to provide shallow foundation, hence pile foundation is proposed in those areas. The requirement of Pile Foundations is mentioned in Part-1, additional scope details for civil works under works-A. Hence, the bidder shall follow the same philosophy for pile foundations.

Where site filling is envisaged, in such cases, the proposed site shall be filled and compacted up to the FGL with proper consolidation and site filling methodology, and later, the pile construction activities shall be taken up. The following points are to be taken care of:

i. Before the actual construction begins, pile load tests must be made to verify the design values, the foundation design must be revised according to the test results.

ii. Piles in sands are driven to the maximum possible depth because pile load is proportional to square of the length. In clayey soils, increased length does not increase the capacity as rapidly as in sandy soils. In clays the length is determined by block failure criterion. Provision of a spread or bulb at the bottom increases the pile load considerably.

iii. A minimum of three piles are required under a column in order to resist all the column loads and moments acting on it. If one or two piles are provided under a column, the grade beams have to be provided in one or more directions which have to be designed to resist fully column basements since piles shall resist the vertical loads only.

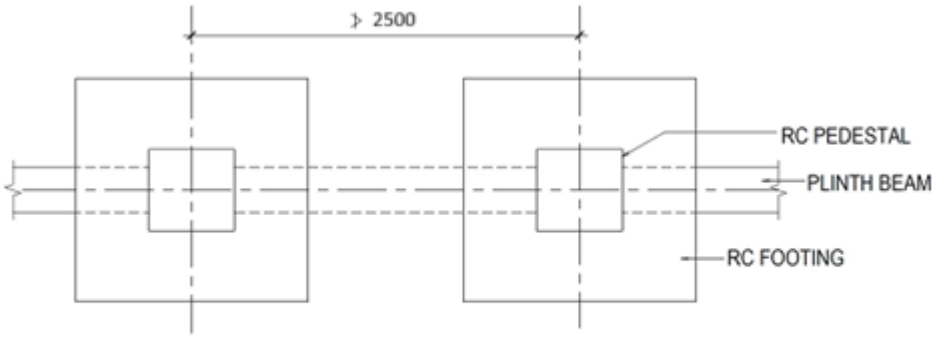
1.37.2 Compaction methodology

The Engineered fill shall be placed in layers of each lift not exceeding 200mm thick with appropriate confinement or self-stabilising slope at the edges. Rollers shall be adopted in order to achieve 97 % modified proctor density, with data for modified proctor density to be initially obtained from laboratory testing of fill material. The number of passes and rollers shall be as suggested in IS-4701(based on soil type). The Quality control tests shall be adopted to verify the achievement of

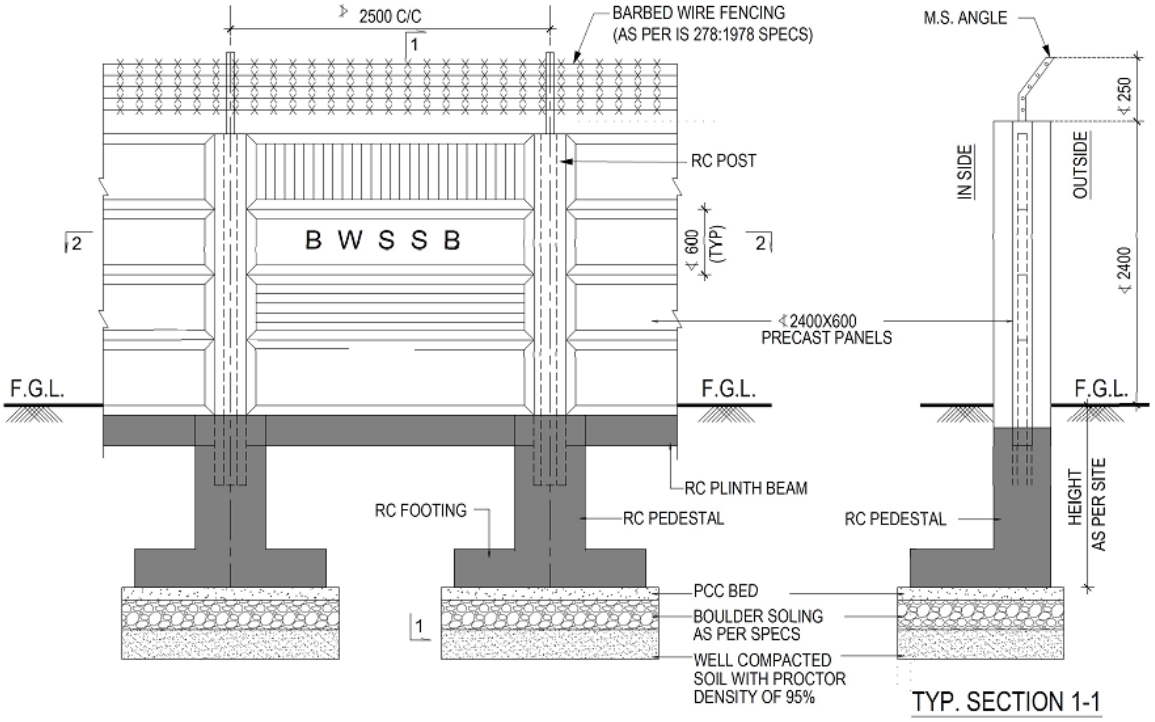
required level of compaction prior to giving clearance for laying next layer. The soil intended for filling shall not have excessive presence of gravels, cobbles/silts and clays.

1.38 DI Pressure Machinehole cover

Pressure machinehole cover and frame DI with SS304 nut bolt arrangement with steel inserts shall be provided in lined and unlined storm water drains. The DI frame and cover of nominal size opening of 560mm internal diameter is proposed to be installed in the storm water drains and it is intended to make the machinehole frame and cover tight. Machinehole cover frame shall be manufactured according to BS EN 124_2 without hinge, with rubber ring gasket for sealing with round shape, including painting with black bitumen coating. The cover and frame shall be provided with threaded arrangement for fixing or arrangement for fixing frame and cover in with SS Bolts. Cover shall be coated with Zinc and black bitumen. The rubber ring gasket shall be as per IS5382 and shall be provided for making the frame and cover watertight. MOC of Anti-theft lock shall conform to IS 304, and anchoring lock MOC shall be MS. Weight of cover shall be in the range of 52-60 Kgs. Refer Sketch-3 for typical details of DI pressure machinehole details.

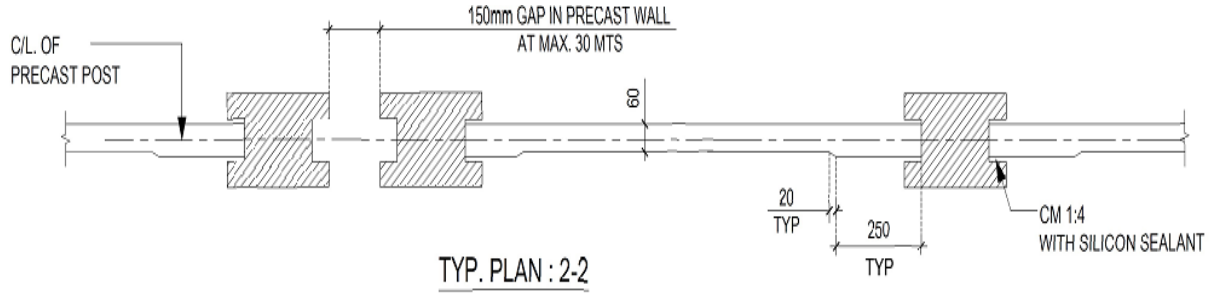


TYP. PART FOUNDATION PLAN



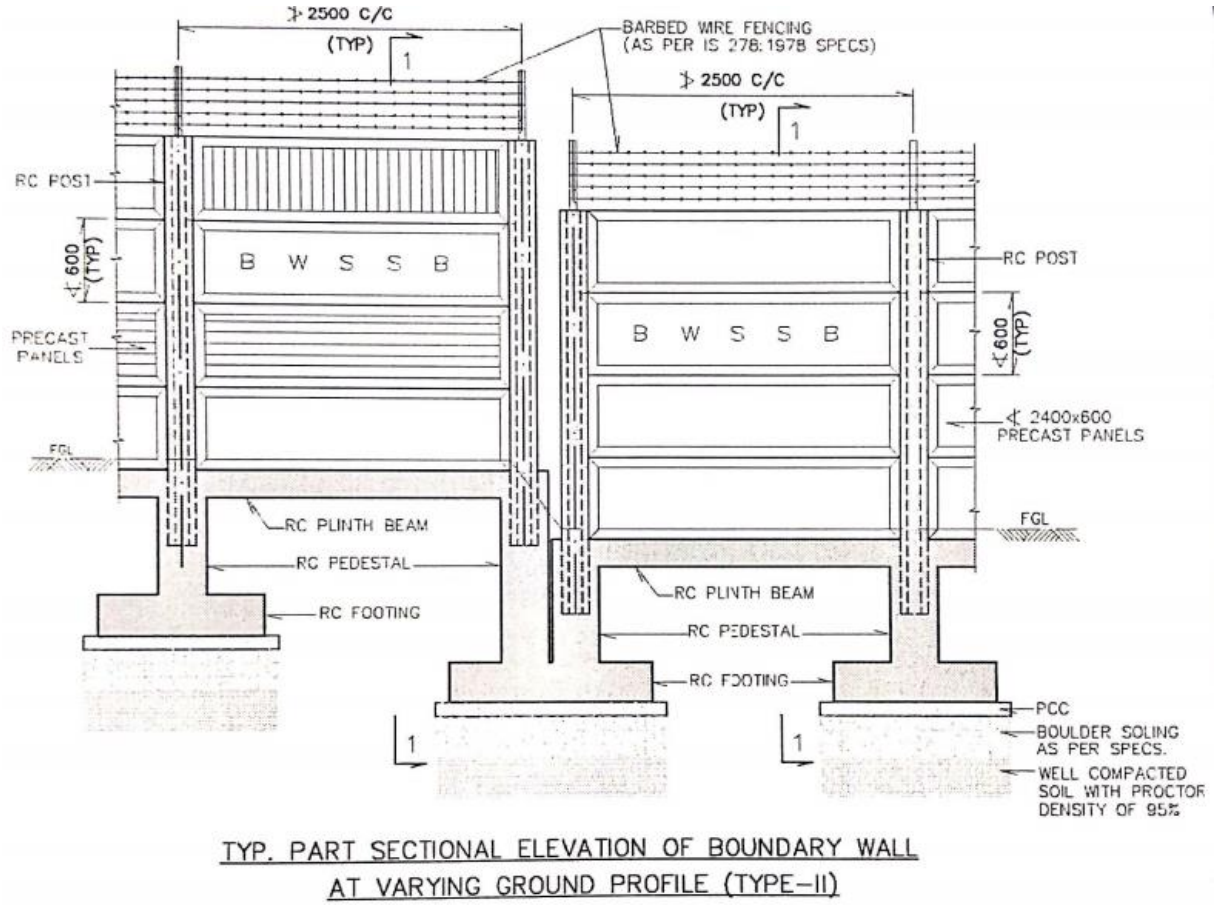
TYP. PART SECTIONAL ELEVATION OF BOUNDARY WALL
AT UNIFORM GROUND PROFILE (TYPE - 1)

TYP. SECTION 1-1



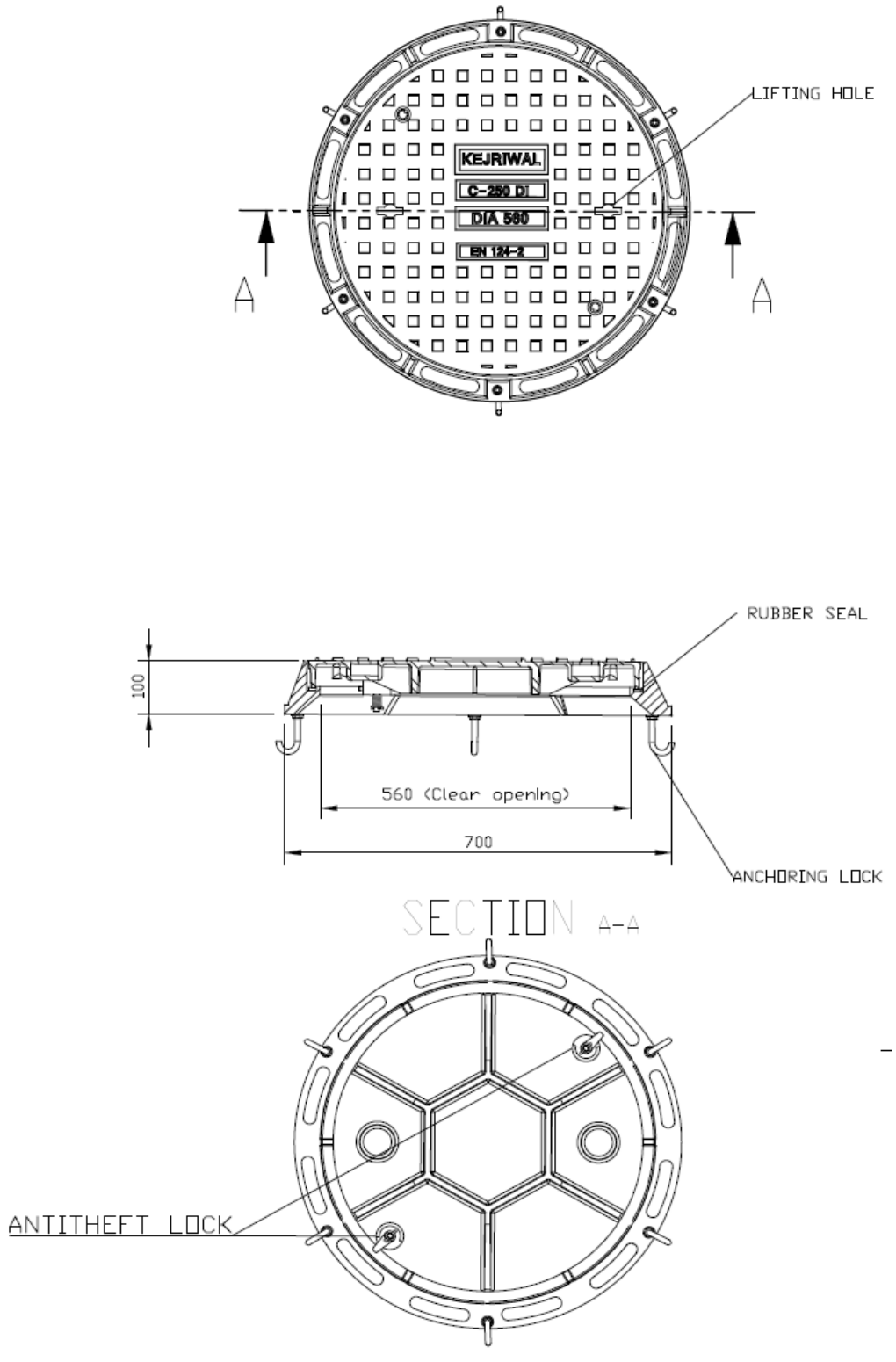
TYP. PLAN : 2-2

SKETCH - 1



TYP. PART SECTIONAL ELEVATION OF BOUNDARY WALL
AT VARYING GROUND PROFILE (TYPE–II)

SKETCH - 2



SKETCH-3 Typical details of DI Pressure Machinehole details

C. Particular Technical Specifications for Pumping main/Sewer Network and Allied Works

SECTION – 1

EARTHWORK EXCAVATION

1.1 Clearing site of large trees, structures etc.

This shall include the removal of large trees, stumps, structures, services such as cables, water supply, sewerage, storm water drains etc. or parts thereof lying along the alignment of sewer. The contractor should inform the Engineer before removing trees, structures, other services and structures etc. well in advance. Large trees and other valuables are the property of the Government, and they should be properly stacked along the side of the road and conveyed to the place as per the directions of the departmental Engineer. The cutting of trees or the demolition of structures is done in such a way that it should not disturb the traffic and pedestrians.

1.2 Removal of Top Soil, Shrubs and Other Vegetation

The work has to be tackled in between two adjacent Machineholes only. All shrubs, vegetation and other plants shall be removed and cleared from the selected stretch of the site. All debris and unsuitable material up to a depth of 30 cm between ground level and road level shall be removed. All debris and unsuitable material shall be carted away from the site as per the direction of the departmental engineer. The clearing and grubbing for trees upto 300 mm girth shall be removed. No separate payment shall be paid towards the above works and work includes loading, unloading, carting the material to a site selected by the contractor, disposal of unserviceable materials at his own cost.

1.3 General

Excavation shall be required to be done for the following works:

a) Excavations for underground sewer lines & pumping mains and other works as directed
b) Excavations for sewer lines below stormwater drains
c) Excavations for Machineholes, footings, pedestals and other works as required etc.
d) No separate payment shall be made for removal of shrubs, grass, large and small bushes, trees, stumps and stems of trees cut up to 300 mm girth, fencing including posts and gates and rate for the same shall be deemed to be included in the other pay items of BOQ

1.4 Preparatory Work, Sight-rails and Boning Staves

The centre line of the trench is first marked out on the ground duly driving pegs at convenient intervals. Before commencement of earth work excavation, levels shall be taken along the centre line of the proposed sewer at intervals of say 10 m and at the Machinehole locations. A longitudinal section (LS) of the profile of the ground surface showing the proposed sewer, indicating the gradients and giving the invert levels of the sewer as well as the Machineholes available at the tender stage, shall be updated based on the contractor's re-confirmatory survey and approved by the Engineer before taking up the work.

The width of the trench to be excavated is marked on both sides of the centre line and excavation lines cut out.

Two wooden posts 100 mm x 100 mm x 1800 mm high shall be firmly, erected/fixed across the centre line i.e on either side at nearly equal distance, from the centre line and sufficiently clear of all intended

excavation such that the poles/posts are not disturbed during the course of execution of the work. These posts are so arranged and fixed that a sight-rail when fixed at a level against these posts shall cross the centre line of sewer or centre of the Machinehole , as the case may be.

The sight-rail made from 250 mm wide x 40 mm thick wooden planks shall be screwed to the poles. The sight-rails shall be truly horizontal. The centre line of the sewer shall be marked on the sight-rail by fixing a nail or otherwise as determined by the Engineer. The sight-rails may be fixed about 1.25 m above the ground, which is convenient distance for sighting by a levelling instrument. The sight-rails have to be so fixed that when a line sighted along the top edge of the sight-rails shall represent the true fall or gradient of the proposed sewer. This gradient is transferred below the ground level by means of boning-rod. Boning is carried out between the sight-rails with the help of a cord or a rope extended from nail to nail fixed on the sight-rails.

Boning rods with cross section 75 x 50 mm of various lengths shall be prepared with wood. Each length shall be a certain number of meters and shall have fixed tee-head. (A cross piece of 450x 100 mm is to be fixed with nails at the top of the boning rod so as to form shape like a Tee-square) and a cross piece about 300 mm long fixed at the bottom of the boning staff. The distance between the top of Tee head and the cross piece shall depend upon the site requirements viz, dia of pipe, depth of cutting, level of sight-rail, designed level of sewer, etc. The boning rod must be marked on two sides to indicate its full length. According to the circumstances of each case, a suitable length of boning rod, duly fixing the cross piece, will be determined upon the reduced level of the invert of pipe at each sight-rail.

The sight-rail and vertical posts shall be perfectly square and planed smooth on all sides and edges. This arrangement of erecting poles with sight-rail shall be done at suitable intervals depending on the site requirements, as directed by the Engineer. The posts and rails must in no case be removed until the trench is excavated, the pipes are laid and permission given to proceed with the filling in.

1.5 Probing Pits

Before starting the excavation of trenches, the contractor shall dig probing pits of size 1 m x 1 m and 1.5 m deep including road cutting at every 100 m interval along the alignment to accurately locate and determine the position of existing utilities and obstructions. The contractor shall refill the probing pits in layers of 15 cm with excavated earth up to the original ground level. In all cases the probing pits are to be excavated in accordance with the specification for excavation, refilling etc. No separate payment will be made for these probing pits and shall be deemed to be included in other pay items of the BOQ.

1.6 Utilities Protection

All utilities within the site, such as water, storm and sewage mains, shall be ascertained by probing pit results at various intervals or as required.
All utility lines and structures, whether indicated on the drawings or not, which are to remain in service shall be protected by the contractor from any damage likely to result from his operations. Any damage to any utility resulting from the contractor's operations shall be repaired at the contractor's expense.

1.7 Pavement Removal

The contractor must inform the Engineer before the starting of work well in advance so that it can be communicated to other concerned departments. The contractor must provide and maintain proper and efficient traffic control system such as safety lamps, sign boards etc. operating day and night for the full duration of work. The BWSSB shall not be responsible under any circumstances for any mis happenings. For the purpose of payment for removal of pavement, steel tapes are to be used and the measurement

shall be taken jointly by the Engineer's representative and contractor or his representative. The maximum width of trench excavation shall as per relevant Indian standards or outer dia of the pipe + 0.3 m whichever is lower and only such widths shall be taken into account for computing quantities for payment. For other elements of work such as Machineholes, making cross connections, fixing other appurtenances etc. the engineer shall prescribe the dimensions for removal of pavement from time to time.

1.8 Maintenance of Traffic and Closing of Streets

The work shall be carried out in such a manner which will cause the least interruption to traffic, and the road/street may be closed in such a manner that it causes the least interruption to traffic, Where it is necessary for traffic to cross open trenches, suitable bridges shall be provided. Suitable signs indicating that a street is closed shall be placed and necessary detour signs for the proper maintenance of traffic shall be provided.

1.9 Soil Investigations

Soil analysis reports of proposed sewer alignment are available with BWSSB office. Additional soil tests, if necessary, shall be carried out along the alignment, and the soil boring logs shall be prepared by the contractor at his own cost. Where off-site materials have to be used, the contractor shall, if the Engineer desires, make available certified soil test reports including information regarding sieve analysis, plastic limit, liquid limit, maximum density, optimum moisture content, etc., from an approved testing laboratory.

1.10 Classification

The excavation work shall be classified into the following categories:

Sewer lines, Machineholes, pedestals and other works.

i) All soils: Loamy, clayey soils like BC soils, red earth, ordinary gravels, hard gravel, a mixture of gravel and soft disintegrated rock, ordinary gravel, stony earth, and earth mixed with boulders of 30 cm size, excluding disintegrated rock.

ii) Disintegrated rock, soft rock, soft shale, and medium hard rock comprising of lime stone, sand stone, hard shale schist, fissured rock or soft rock or conglomerate rock, to be removed by pick axes and crow bars, wedges and hammers with some difficulty including all types of laterite excluding hard rock

iii) Hard rock to be removed only by chiselling and benching/breaker, diamond rope cutting or as directed by the engineer.

1.11 Trench Excavation

General

Trench excavation means excavation of trenches into which the pipe is to be laid. The line and levels of trenches shall be as shown on the drawings or as may be directed by the Engineer. Before commencing trench excavation, the route of the trenches shall be pegged out accurately and the natural ground levels shall be agreed with the Engineer.

1.12 Width of Trench

The width of trenches measured at the crown of the pipe shall permit adequate working space. The trenches shall be widened at sockets and other structures as may be found necessary. The widths to be adopted are shown in respective drawings. If the widths of actual excavation are more than the specified, it has to be made by the contractor with no separate payment. Care should be taken to avoid excessive trench widths and thereby increasing the load on the pipes. The maximum width of trench excavation shall be as per relevant Indian standards for pipe laying or outer dia of the pipe + 0.3 m whichever is lower and only such widths shall be taken into account for computing quantities for payment. However, the minimum width of the trench shall be 600 mm.

1.13 Depth of Excavation of Trench

The depths for the trenches will be calculated from the surface to the bed of the pipes and in case when a layer of bedding is to be placed below the pipe line, the depth to the bottom of the bedding will be paid. The depth of excavation for Machineholes shall be measured from the surface of the existing ground level to the bottom of foundation. No payment will be given beyond this depth.

1.14 Maximum Length of Open Trench

The stretch of work to be tackled shall be limited to two adjacent Machineholes. However, the Engineer may permit only reasonable trench excavation in advance of the lengths between two adjacent Machineholes to ensure that laying and jointing of pipes can reasonably be expected to be completed and the trench refilled, and not attended to later than 3 days after excavation of the trench. The Contractor will not be permitted to keep trenches open for unduly long periods, creating public hazards. The Engineer's decision in this respect shall be final.

1.15 Trench Sides

Loose boulders shall be removed from the sides of the trenches before allowing workmen into the excavation, and the trench sides shall be stabilized with screening or other methods approved by the Engineer. Trench slopes shall be kept moist where necessary to prevent local sliding as ordered by the Engineer.

1.16 Widening Trench at Joints, etc.

Any widening or deepening of the trench, whether in ordinary soil or rock, necessary to accommodate curves, joints or bends as shown on the drawings or ordered by the Engineer shall be carried out by the contractor.

1.17 Over-excavation of trench bottoms

All excavation carried below the grades shown on drawings, shall be refilled with compacted bedding material at the Contractor's expense.

1.18 Excavated material

The material from the excavation shall be deposited on either side of the trench leaving clear berm on one side at least 40 cm wide or at such further distance from the edges of the trench as may be necessary to prevent the weight of materials from causing the side of the trench to slip or fall, or at such a distance and such a manner as to avoid covering fire-hydrants, sluice valves, Machinehole covers and the like and so as to avoid any wall or structure or causing inconvenience to the public or other persons or otherwise as the engineer may direct, till it is carted away.

The excavated soil should be so placed and handled as not to inconvenience the usual traffic, till it is carted away. The contractor should also provide necessary bridging over the excavated trenches for the house-holders and pedestrians to cross over and vehicular crossings if and where required at no extra cost, if the Engineer decides that there is no hindrance to traffic due to not carting away the excavated earth, he will give instructions to that effect.

The Machinehole frames and covers from the existing Machineholes shall be carefully removed and stored in a suitable place away from the trenches. The contractor should not break the Machinehole frames and covers while removing. The contractor is responsible for the safety of Machinehole frames and covers.

1.19 Pipe Bedding

i) Granular Bedding

The bed of trenches shall be prepared as per drawing. Sand used for back fill shall be natural sand (free from cinders, ashes, slag, refuse, organic materials, boulders, rocks or stones) graded from fine to coarse or manufactured sand as per BOQ & contract specifications. The total weight of clay in it shall not exceed 10%. All materials shall pass through a sieve of aperture size 6.30 mm.

ii) Gravel/Murram Bedding

The bed of the trenches shall be prepared as per drawings. The approved granular material shall be of size less than 25mm (murrum) and work shall include watering and consolidation by punners etc., complete with all lead and lifts, as per specification and as directed by the Engineer complete

iii) Stone dust or quarry dust Bedding

The bed of the trenches shall be prepared as per drawings**.** Bedding or Back filling shall be using approved stone dust/quarry dust of size not exceeding 5.6mm for the pipe line trenches and work shall include watering and consolidation to 95% proctor density etc., complete with all lead and lifts as per specification and as directed by the Engineer complete

iv) Concrete Bedding

This type of bedding is as per the drawing appended with the tender document, and is to be provided at locations shown in drawings or as specified by the Engineer. A concrete bedding as per BOQ provisions shall be provided mostly in weak strata and in storm water drains. The concrete work related to this specification is detailed in the specifications of concrete and allied works.

In case of sewers laying in storm water channels, the pipe shall be encased with cement concrete/reinforced cement concrete of grade as per BOQ provision with a minimum thickness of 150 mm all around or as per bedding drawing. If the clear distance between drain bed and pipe top is more than one meter then concrete bedding as directed by the Engineer shall be done.

1.20 Trench excavation in hard rock

If any material which in the opinion of the Contractor can be classified as hard rock is encountered, he shall immediately inform the Engineer and the level, extent and description of the material encountered shall be measured jointly and recorded before excavation.

Only such proportion of material notified and measured which is certified by the Engineer as "rock", shall be paid for as rock excavation.

Excavation for trenches in rock shall be so carried out such that the clearance between the pipe, when laid in position and the sides and trench bottom shall be kept to the minimum limits necessary to provide for specified thickness of bedding, and surround to the pipe as specified. Excavation outside the specified limits shall not be paid for and any additional expenses incurred in providing additional strength to the pipe to overcome the increased trench loads on account of increased width shall be at the Contractor's expenses. The rock thus excavated shall be auctioned as directed by Employer/Engineer as per GOK procedures and the auctioned amount shall be remitted to the Employer/Engineer.

1.21 Excavation for appurtenances

Excavation in trenches for foundation anchor blocks, pedestals etc. shall be as per the plan or as directed by the Engineer. The dimensions of the excavation shall be measured as the projection in plan of the outermost edges of the structure.

1.22 Pumping sewage or diversion by gravity and dewatering

General
The works included in this Section are as follows:

1) Provision of all labour, equipment, materials etc. to ensure a safe and dewatered condition in all areas in which the work in this contract are to be executed.
2) Continuous operation of the dewatering systems is required to complete all portions of the works where dewatering and pumping of sewage is necessary to prevent inflow, collection of surface water or ground water, or sewage or to protect adjacent properties or constructions from damage resulting from a rise or fall of ground water levels or sewage.
3) Removal of the equipment when no longer required.

1.23 Pumping out water and dewatering

The Contractor shall provide and work at his own cost, all pumps, engines and machinery requisite to keep the trenches for the sewers or foundations and all other excavations clear of water, whether sub-soil water, storm water, sewage, leakage from tanks, wells, drains, sewers, water mains or pipes etc., so that there may be no accumulations of such water and that no setting out may be done, no masonry may be laid, no concrete deposited, no joints made and no measurements taken in water.

The pumping shall be continued so long after execution of any portion of the work and repeated as often as the Engineer may consider necessary. The pumps and power applied must be such as the Engineer may determine to be sufficient to any particular time so that he may stop the work altogether until he is satisfied and also impose a fine upon the contractor.

The Contractor shall be responsible for the adequate pumping, drainage and bailing out of water from the excavation with all rates of recuperations. Dewatering shall be either continuous or intermittent using method approved by the Engineer. The method of dewatering shall depend on site condition should be furnished by the Contractor and approved by the Engineer. The method of dewatering shall be either sump pumping or well point dewatering. The effectiveness of each method will depend upon the nature of the soil, the proportions of the trench and degree of lowering required. Pumping test may be necessary to determine which method is suitable. If sump pumping is not practicable other control methods shall be considered and should be approved by the Engineer. The trenches should be kept dry till the completion of work, which includes excavation, pipeline laying, jointing, testing and

commissioning and backfilling. Precaution should be taken against the flotation of the pipes. The Contractor shall conduct ground studies if necessary and the cost for such studies have to borne by the Contractor himself.

The Contractor shall be responsible for the adequate pumping, drainage and bailing out of water due to the excavation for laying sewer pipe lines and all types of constructions. In case of failure to make such provisions or any other provisions, which may result in unsuitable sub-grade conditions, the Contractor shall replace and repair the sub-grade as directed to the satisfaction of the Engineer, at his own cost and responsibility.

Should the Contractor select to use a gravel sub-grade with or without unjointed pipes with the gravel layers to facilitate flow of water to pumps or other points of disposal, such gravel sub grade with or without conveying pipes shall not be measured or paid as an extra item and rate for the same shall be deemed to be included in the other pay items of BOQ.

1.23.1 Sump pumping

This method may be used in highly and moderately permeable soils such as gravels, sand and gravel mixtures. This method is simple and cheap to install and used with watertight trench sheeting to limit the volume of flow. To prevent the boiling in the bottom of the trench the following precaution should be taken.
Drive sheeting deeper to lengthen drainage path;
Use open pipe surrounded in gravel as a sump;
Move the sump to one side of the trench;
To prevent removal of fines from soil causing loss of strength in the soil and undermining of the trench bottom and side support, surround suction inlet with protected graded filter;
Increase flow rate through the soil by using open pipe surrounded with gravel.

The delivery side of the pump should be monitored by taking samples of water and checking the proportion of fines being removed. If fines are being continuously withdrawn or there are signs of trench instability, sump pumping should be stopped and alternative methods considered.

1.23.2 Well pointing

In this method well points are installed at regular intervals on one or both sides of the trench and linked parallel to a header main connected to a pump. Well points are usually installed at 0.6 to 2.0 m centre to centre by jetting them in. In ground with dense layers or cobbles & boulders, it may be necessary to pre-bore the layers. The efficiency of the well points is increased by sanding in the well point and riser using a column of sharp sand. This method has an advantage of drawing water away from the trench and in suitable conditions is effective in lowering the water by 4 to 6m below excavation level. It will also reduce the hydrostatic heads on the trench support system. Its greatest use in sand, the heavy flows impermeable ground, such as gravels, means that the well points have to be so close together that the method becomes impractical. In clays the rate of seepage is too small for the system to be properly effective. Silts can be stabilized in certain conditions by using special procedures.

The well pointing shall be either single sided well point or double sided well point. For higher depths double sided well point with multi stage shall be considered. Should the Contractor select to use a gravel sub-grade to facilitate flow of water to pumps or other points of disposal, such gravel sub-grade shall not be measured or paid for as an extra item. Contractor should assess the availability of extra earth required for refilling in case of shortage in any particular reach well before quoting rates.

Even in case the Contractor resorts to mechanical excavation, the Contractor should take care of proper refilling, consolidation and disposal of surplus earth.

Disposal of ground water is to be away from the area of influence of the pipe laying area Suitable temporary pipelines are to be laid to existing watercourses. For lowering the sub soil water level for the construction of wet wells the bores have to be installed/jetted at distance between two bores varying from 0.6 to 1.0m depending upon sub strata and the incoming flow of water. The bore should be installed at least 1.0m away from the periphery of the excavated earth. The dewatering includes removal of ground water, springs, seepage water, sullage, sewage, running water, rain water etc., in order to make the trench for pipe line works etc. It is to be noted that contractor can adopt the suitable type of dewatering to keep the trench dry until completion of all sewer laying and testing works.

1.24 Keep excavation clear of water

Where ground water/Nallah surface flow is encountered or anticipated the contractor shall provide sufficient pumps to handle the ingress of water and must provide and maintain in working order. Standby pumping units are to be made available and employed in the event of mechanical failure. The contractor must also arrange for night and day operation of the pumps wherever necessary to ensure that the work proceeds at all times.

1.25 Barricading, watching, lighting

The parts of the barricading shall be of timber, securely fixed in the ground not more than 2.50 m apart. They shall not be less than 10 cm in diameter and not less than 1.5 m above the surface of the ground. There shall be two rails, one near the top of the posts and the other about 0.50 m above the ground and each shall be of 5 cm to 10 cm in diameter and sufficiently long to run from post to post to which they shall be tied with strong ropes or the work shall be carried out as per BOQ provisions.

The method of projecting rails beyond the posts and tying together where they meet will not be allowed on any account. All along the edges of the excavated trenches, a bund of earth about 1 m high shall be formed when so directed by the Engineer for further protection. Proper provision shall be made for lighting at night and watchmen shall be kept to see that this is properly done and maintained. In addition to the normal lighting arrangements the contractor shall provide, whenever such work is in progress, battery operated blinking lights (6 volts) in the beginning and end of a trench with a view to provide suitable indication to the vehicular traffic. The contractor shall also provide and display special boards printed with fluorescent prints indicating the progress of work along-the road. Further, in all such cases the work may be carried out departmentally at the risk and cost of the contractor. The contractor shall be held responsible for all claims for compensation as a result of accident or injury to person and non-provision of red flags.

The Contractor shall at his own cost provide all notice boards before opening of roads as directed by the Engineer.

Arrangements shall be made by the contractors to direct traffic when work is in progress. No separate payment shall be paid for this item of work.

1.26 Refilling trenches

1) With a view to restrict the length of open trenches, on completion of the pipe, laying operations, refilling of trenches shall be started immediately by the contractor. Pipe laying and testing shall follow closely upon the progress of trench excavation and the contractor shall not be permitted unreasonable excessive lengths of trench excavation to remain open while awaiting testing of the pipe line.

2) The trench shall be filled by borrowed gravel or approved material up to at least 30 cm. above the top of pipe, back filling is to be done keeping at least 90 cm. length of pipe open at the joints, for verification of joints for water tightness during testing.

3) Care shall be taken while back filling, not to injure or disturb the pipe. Filling shall be carried out simultaneously on both the sides of the pipes so that unequal pressure does not occur.

4) Walking or working on the completed pipeline shall not be permitted unless the trench has been filled to a height of at least 30 cm over the top of the pipe except as may be necessary for tamping, etc., during back filling work.

5) Filling-in shall be done in layers not exceeding 150 mm in thickness accompanied by adequate watering, ramming, etc., so as to get good compaction up to 300 mm above the top of the pipe. Above this level, useful excavated earth free from boulders shall be placed in layers of 150 mm, watered and compacted by tamping. Wherever pipe is laid in the storm water channel, total refilling shall be done with borrowed earth or as directed.

6) The trench shall be refilled so as to build up to the original ground level, keeping due allowance for subsequent settlement likely to take place.

7) Before and during the backfilling of the trench, precautions shall be taken against the floatation of the pipeline due to the entry of large quantities of water into the trench causing an uplift of the empty or the partly filled pipeline.

8) In case of sewers laid in storm water channels, after refilling is done, the bed of the channel to the extent trench width shall be made with cement concrete of grade M15 with a thickness of 150mm as per the site requirement and as directed.

9) Optimum Moisture Content (OMC) test to be carried at trench section and Maximum Dry Density (MDD) test for the refilled soil in trench to confirm the proper compaction up to 95% of maximum dry density.

1.27 Refilling the road surface

After the backfilling is completed, the contractor shall restore the surface of the trench over the pipe to that road surface existing prior to excavation, i.e., either bitumen or cement concrete as the case may be and verified from the adjacent surface. This will be paid as per the Bill of Quantities. The width for the payment of road cutting or restructuring will be only as per the direction of the Engineer. The work of restructuring of road surface either by bitumen or cement concrete shall be as described in chapter Road restoration.

1.28 Subsidence in filling

Should any subsidence take place in the filling at any place of work i.e. at Machineholes and over pipe trenches and road surface whatsoever during contract, the contractor shall make good the same at his own cost or the engineer may with or without notice to the contactor make good the same in any way and with any material that he may think proper, and at the expense of the contractor. The

engineer may also, if he anticipates the occurrence of any subsidence, take necessary action deemed fit in which case also the expenses therefore shall be charged to the contractor.

1.29 Disposal of excavated materials

Excavated materials shall be used for refilling etc. and surplus earth shall be disposed off to the outskirts of corporation safely with all leads and lift as directed by the engineer. In case of pipe laying work to be carried at the outer periphery of the lakes, the excess material shall be used for filling and embankment formation along the outer periphery of the lakes for laying of the sewer network

1.30 All works to be clear, clean and perfect

The Contractor, after completion of entire work and before seeking settlement of his final bill, shall prove at his expense that the entire line is clear, clean and perfect in the presence of the Engineer or his authorized subordinate. He should provide suitable instruments, appliances etc., and pass them through the pipes and shall show that water passes freely through the entire reach from higher end to lower end. Necessary precautions such as those indicated hereunder may be taken by the Contractor while checking the completed sewer line for its effective functioning, wherever required.

The Machineholes should be kept open, as required for one hour or as required, prior to the starting of checking operations and should be so kept open during the whole duration of checking operations. This is to be done for allowing the gases to escape, naturally. In order to prevent fire and explosions, endangering the life, properties, sewers and other utility services due to presence of combustible gases, no lighted match sticks or other similar material should be thrown in the Machinehole . All necessary safety equipment's, gadgets and sensors shall be used in the restricted working areas.

Meshes should be placed over the opened Machineholes to prevent pedestrians etc., from falling in. Likewise, caution boards printed in fluorescent letters such as "DANGER MACHINEHOLE IS KEPT OPEN" etc., shall be provided.

1.31 Laying of sewer pipes along the water body

It is to be noted that sub-mains/trunk lines need to be laid along the edge of tank/water bodies. If permitted, the edge of the tank shall be first filled with earth and later pipe laying work can be taken up and the excess soil shall be used for this purpose.

1.32 Measurement

The measurement of excavation shall be made on quantity basis as per the actual dimensions of the trench excavated limited to the width shown in the drawings or as directed.

a) Trench excavation

The length of the trench excavation shall be measured along the centre line of pipe at various depths stated in the Bill of Quantities, the total length being segregated into stretches according to the various depths of excavation contained in the Bill of Quantities to fall into the specified categories. Within each stretch the depth applicable shall be within the range specified in Bill of Quantities.

The depth of excavation shall be measured from the top of the trench at the centre before excavation upto the bottom of the bedding under the pipe. If no bedding is provided, the measurement shall be to the level of the bottom of the pipe line. The width of the trench shall

be measured on the basis of vertical side walls and the specified widths. No additional payment shall be made for the widening at sockets, specials, hunching or surrounds beyond the dimensions specified.

b) Structures

Measurement for structure excavation shall be made as per the projection in plan of the outermost edges of the, structure as per the plan at the bottom.

c) Rock excavation

The depth of rock excavation measured for payment shall not exceed the corresponding depth in ordinary excavation or as directed by the Engineer.

In all above cases, no payment will be made for additional selected fill, lean concrete, bedding cradling or hunching concrete that may be specified or ordered by the Engineer as a consequence of excavating beyond the limits specified in the contract documents or ordered by the Engineer.

The contractor has to auction/dispose/use himself the excavated hard rock as per GOK guidelines and the revenue generated in this manner will be recovered in his payment at the prevailing rate of Royalty with applicable GST.

d) Disposal of excavated material

All the excavated material shall be carted away with all lead and lift and it includes loading, unloading, transporting with all lead and lift and as per Engineers directions.

SECTION 2

CONCRETE AND ALLIED WORKS

2.0 General

The quality of materials and method and control of manufacture and transportation of all concrete work irrespective of mix, whether reinforced or otherwise shall conform to the applicable portions of this specification.

The Engineer shall have the right to inspect the source/s of material/s, the layout and operation of procurement and storage of materials, the concrete batching and mixing equipment, and the quality control system. Such an inspection shall be arranged and Engineer's approval obtained, prior to starting of concrete work. However, this shall not relieve the contractor with any of his responsibilities and all the materials, which do not conform to the specifications, will be rejected. The detailed specifications are provided in Part 10-A, Standard Technical Specifications

SECTION- 3

SEWER APPURTENANCES

3.1 Machineholes

The Machinehole shall be provided with RCC Machinehole depending upon diameter of sewers and depending upon the alignment of proposed sewer whether it is on road or in Storm Water Drain (SWD)/in WwTP/ISPS premises.

The Precast/Cast In-situ RCC are defined with the following conditions.

- RCC Precast Machineholes –for all depths
- RCC Cast in situ Machineholes – In storm water drains, for all dia. of pipe and for all depths.

It is intended to Construct RCC precast/Cast in situ Machineholes for the proposed sewerage system

(i) Location

Machineholes shall be constructed at places as shown on relevant drawings and as directed by the Engineer.

(ii) Excavation

Excavation, shoring, dewatering etc. for the pits of Machineholes shall be done in accordance with specification.

(iii) General

In general, plain and reinforced concrete work for Machineholes shall be carried out in accordance with the specification and drawing. The RCC Precast/Cast in Situ Machineholes shall be of minimum RCC M30 grade concrete using sulphate resistant cement.

Construction of RCC Machinehole chambers of in M30 grade proportion or approved type pre-cast RCC Machinehole chambers, constructed using form vibrators of standard type, with barricading, danger lighting and using of sight rails and boning rods whenever necessary, shoring and strutting wherever required using sulphate resistant cement, with minimum M30 grade RCC with 20 mm and downgraded jelly, well graded sand and steel of approved quality, minimum 200 mm thick top concrete slab or as per approved drawings, having wall thickness and raft thickness as in approved drawings and with an offset in raft all-round the chamber as in approved drawings.

Benching concrete with 1:6 slope towards the central drain finished smooth, including fixing and grouting of pipes, including conveying to work spot supply and fixing of SFRC Machinehole cover and frame (Heavy duty) confirming to IS 12592 with latest amendments, on a bed of CC 1:2:4 supplying and fixing of minimum 3 mm thick encapsulated plastic footsteps (as per IS 10910) on 12 mm dia Grade FE-500 steel bar (as per IS 1786) staggered at 300 mm apart as detailed in technical specifications, including sand & boulder bedding wherever required, disposal of surplus earth, dewatering until completion of works, curing, engraving Machinehole number with flow direction on the inner cylindrical surface etc complete including cost of reinforcement steel and fabrication charges, shuttering, shoring, keeping the trench dry until completion of works, including cost of transportation and erection of pre cast members from yard to site and also cost and conveyance of all materials, labour complete with all lead and lift. The precast RCC Machinehole/Cast in situ

chambers are for various diameters and depths as per detailed drawings, specifications and direction of the Engineer

The RCC Precast Machineholes shall be of minimum RCC M30 grade concrete. The Machinehole shall be constructed using sulphate resistant cement. The rubber seal joints shall be provided in between precast units, rubber gaskets shall be as per IS 5382. The joints shall be sealed with non-shrink grout. Single rubber seal shall be provided in between precast units. All reinforcement bars shall be HYSD CRS bars of grade FE 500 confirming to IS 1786. The non-core opening shall be 100 mm greater than the outer diameter of the pipe. The lifting holes shall be filled with Concrete. It may be noted that single offset joint configuration shall be adopted at the joint. Based on the site requirement, direction of the Engineer, or at the request of the contractor, contractor can construct cast in-situ Machineholes in place of precast Machineholes with contractors approved design and drawings in restricted areas. Provision for house service connection pipes if required shall be provided as per the direction of the Engineer.

The Machineholes shall be constructed at places as shown on the Sewer network drawings, issued during execution or wherever directed by the Engineer.

(iv) Cement concrete channel

The channel for the Machinehole shall be constructed in cement concrete of M15 grade. Both sides of the channel shall be taken up to the level of the crown of the outgoing sewer. They shall be benched up in concrete extended vertically 50mm above and rendered in cement mortar (1:2) of 20 mm thickness and formed to a slope of 1 in 6 towards the channel.
The branch channels also be similarly constructed with respect to the benching but at their junctions with main channel, an appropriate fall, if required suitably rounded off, in the direction of flow in main channel shall be given.

(v) Pipe entering or leaving Machinehole

Whenever a pipe enters or leaves a Machinehole, the pipe shall be encased with the concrete all around the pipes covering the joints.

(vii) Rungs / foot steps

Rungs / footsteps shall be provided in all Machineholes and shall be Manufacture and conforms to the dimensions of IS 5455:1969 are reinforcement encapsulated with PVC. The surface finish shall have 2mm tread on top by ribbing or chequering. These rungs may be 300 mm apart vertically and shall project a minimum of 100 mm beyond the finished surface of the machinehole wall. The top rung shall be 450 mm below the machinehole cover and the lowest not more than 300 mm above the benching. Rungs shall be tested as per IS and approved before usage.

(viii) Frame and covers

Frame and covers for Machineholes shall be of required type and dimensions as per the relevant drawings.

Following information shall be clearly marked on each cover.

a. Year of manufacture
b. Identification mark of the purchaser
c. SEWER / SWD

d. Arrow showing direction of flow
e. Name of manufacturer / Trade mark

(xi) Steel Fibre Reinforced Concrete (SFRC) Frame and Cover

Steel Fibre Reinforced Concrete (SFRC) frame and cover shall be as manufactured as per IS 12592. (Latest edition). The contractor to submit the structural design and drawing of frame and cover and get it approved before manufacturing the same.

(xii) Drop Machinehole

When a sewer connects a main sewer, and where the difference in level between water line (peak flow levels) of main line and the invert level of branch line is more than 600 mm or a drop of more than 600 mm is required to be given in the same sewer line and it is uneconomical or impractical to arrange the connection within 600 mm, a drop connection shall be provided for which a machinehole shall be constructed as per relevant drawing, incorporating a vertical drop pipe from the higher sewer to the lower one. A continuation of the branch sewer should be built through the shaft wall to form a rodding and inspection eye, which should be provided with a half blank flange. The diameter of the back drop should be at least as large as that of the incoming pipe. The drop pipe should terminate at its lower end with a plain or duck-foot bend turned so as to discharge its flow at 45 degrees or less to the direction of the flow in the main sewer.

(xiii) Measurement - Machineholes

The depth of machinehole shall be measure from the top of cover to the invert level of the deepest outgoing sewer from the machinehole. The measurement shall be per number basis and as per the actual depth of machinehole constructed.

Notes:

If any damage is caused to the other services such as water supply pipeline, sewer, cable/ other utilities etc. during the construction of Machineholes Contractor shall be held responsible for the same and shall replace the damaged services at his own cost to the full satisfaction of the Engineer.

The interior of Machineholes shall be cleared of all debris after construction and before testing the same for water tightness by Contractor at his own cost.

Water for testing of Machineholes along with pipeline shall be arranged by Contractor at his own cost.

3.2 Existing connections

All existing connections which are removed during the uprooting of the existing sewer if any shall be replaced and reconnected with new sewer as per the directions of the Engineer. The replaced new sewer connections shall be properly laid, jointed and connected as per the directions of the Engineer. During the execution work of replacing sewer if the bedding of the connection has been disturbed it shall be replaced with new bedding as per specification contained in the tender document. After making the connection to the sewer, back filling shall be done in layers as directed by the Engineer.

3.3 Ventilation shafts

Ventilation shafts are to be provided for the Machineholes in SWD or at places as directed by the Engineer. The connecting pipe from machinehole to ventilating shaft shall be DI K-9 150 mm diameter. A foundation block of 150mm thick PCC in M15 is provided surrounding the pipe. The vertical shaft should be made of ductile iron and it should be around 6 m high above the ground level and the internal diameter of the shaft should be 150 mm. All the dimensions are to be taken as per tender drawing. The joint of pipes forming the ventilating shaft should be made air tight. The location of the ventilating shaft should be such that it should not cause any nuisance to the vehicular traffic and the movement of pedestrians. The placing of ventilating shaft should be as per the directions of Engineer in charge. The details of fixing the ventilating shafts are provided in the drawing under volume 4 of the tender document.

3.4 Concrete cradles, haunching, etc.

The concrete cradles shall be constructed in situ by the contractor, indicated in the drawings, in places wherever required as decided by the Engineer.

Precast Concrete Blocks (Anchor blocks)

It is proposed to lay part of the DWC pipes besides/inside storm water drains or in water logged areas. It is intended that the contractor shall dewater/divert and keep the trench dry before laying of the pipes. The contractor shall provide the anchor blocks or uplift arrangements as per the Good for construction drawings, issued during execution and as directed. The contractor shall provide precast anchor blocks or uplift arrangements as per the BOQ provisions and as per drawings.

SECTION -4

SPECIFICATION FOR SFRC MACHINEHOLE COVERS

4.1 Scope

Contractor's scope includes the design, manufacture, supplying and fixing the SFRC machinehole frame and covers. The wet concrete mix is subjected to pressure applied through a hydraulic jack through a plunger kept at the top of the wet mix. The SFRC machinehole covers shall be able to resist 20 tonnes load bearing capacity. The dimensions shall be as per IS:12592. A 25x3 mm thick MS Flat all around the frame is welded to the main reinforcement of the frame so as to get a clear opening of 560 mm diameter. A 18 SWG MS strap all around the cover and lifting arrangement of 12 mm diameter MS bars welded to the main reinforcement are also to be provided for lifting the machinehole covers. A coat of epoxy paint shall be applied to the underside and sides of the frame and cover.

4.2 General

a) The quality of materials, method of testing shall be approved by the Engineer.

b) The Engineer shall have the right to inspect the source/s of material/s, the layout and procurement, the equipment, quality control system, testing of material etc. If the Engineer desires the sample of the SFRC cover or materials used for the manufacture of SFRC covers, test certificate from approved laboratory. Then the contractor shall arrange the same without any extra cost.

4.3 Material

a) Cement

Unless otherwise specified in the specification or called for the engineer, cement shall be ordinary Portland cement as per the relevant IS code. More details are mentioned on the section of concrete under this tender document.

b) Fine aggregates

The details of this have been mentioned in the section concrete and allied works of this tender document.

c) Coarse aggregate

Coarse aggregate for concrete, shall conform to IS:383. This shall consist of crushed stone and shall be clean and free from elongated flaky or laminated pieces, adhering coating, clay lumps, coal residue, clinkers, slag, alkali, mica, organic matter or other deleterious matter, the maximum size of the aggregate shall be 12 mm.

d) Water

Water for use in concrete and curing shall conform to IS:456/1964 and its subsequent amendments.

4.4 Water/Cement ratio

The water-cement ratio shall *be 0.40 to 0.45 to* yield a good workability. The workability can be increased by using appropriate admixtures.

4.5 Fiber Reinforcement

The fibers are cut from 0.40 mm dia high tensile steel wires of about 12000 kg/cm2 ultimate stress. The fiber content for the manufacture of FRC covers is of the order 1 to 1.25% by volume of the concrete.

4.6 Design Mix

The vendor shall design the mix design of the concrete which is expected to give a concrete compressive strength as per IS:12592

4.7 Mixing

Concrete shall be mixed in a mechanical mixer. Mixing shall be continued until there is a uniform distribution of the materials and the mass is uniform in colour and consistency.

4.8 Placing and compaction

The reinforcement shall be placed in proper position in steel moulds coated with a thin layer of mould oil. Concrete shall be filled to slightly overfill the moulds and compacted by vibration and struck off level with a trowel.

Use of needle vibrators for compacting the wet concrete mix containing fibres is not recommended since the holes left by the vibrator in the wet mix may not close after its removal owing to interlocking of the fibres with the mix. Compaction by means of shutter or form or table vibrators is recommended. In case of extra heavy duty and heavy duty cover frames, compaction by means of pressure cum-vibration technique may also be employed so as to achieve dense and strong concrete. Clear cover to reinforcement shall be not less than 15 mm. After de-moulding, cover frames shall be protected until they are sufficiently hardened to permit handling without damage.

4.9 curing

The hardened concrete machinehole cover frame shall be placed in a curing water tank or taken to the curing yard where they shall be kept continuously moist for at least 28 days. Frames may be water cured by immersion in water, covering with water saturated material or by a system of perforated pipes. Mechanical sprinklers or any other approved method that will keep covering frames moist during the specified curing period. Steam curing of machinehole cover frames may be adopted instead of method specified above provided the requirements of pressure or non pressure steam curing are fulfilled and the machinehole cover frames meet the requirements specified in this section.

4.10 Edge Protection and finishing

The top and inside surface of cover frames shall be smooth. To prevent the top outer edge from possible damages, it shall be protected by 25 mm x 3 mm mild steel flat as part of the frame. Sufficient number of steel connectors shall be welded to the inner surface of the mild steel flat so as to connect it with the frame reinforcement and these shall be embedded in the concrete during casting. Exposed surface of mild steel flat shall be given suitable treatment with anticorrosive paint or coating. Suitable arrangements may be made for fixing the machinehole cover frames in position on the Machineholes by mutual agreement between the manufacturer and the purchaser.

4.11 Physical requirements

4.11.1 General

All the frames shall be sound and free from cracks and other defects which interferes with the proper placing of the units or impair the strength or performance of the units. Minor chippings resulting from the customary methods of handling and transportation shall not be deemed ground for rejection.

1. Dimension

The inside dimensions at top shall match with the corresponding covers so that the maximum clearance at top between the frame and the cover is not more than 5 mm and the top surface of the frame and cover is in level within a tolerance of ± 5 mm.

2. Scale of Sampling - LOT

In a consignment of 500 precast concrete machinehole cover frames or a part thereof, of the same type and dimensions and belonging to the same batch of manufacturer, shall be grouped together to constitute a lot. For ascertaining conformity to the materials in the lot to requirements of this specification, samples shall be tested from each lot separately. The number of cover frames to be selected from the lot shall depend on the size of lot and shall be according to the following table:

Scale of sampling and permissible number of defectives

No. of cover Frames in the Lot Dimensional Requirement

	Sample Size	**Acceptance Number**
Up to 100	10	1
101 to 200	15	1
201 to 300	20	2
301 to 500	30	3

SECTION – 5

RCC SOCKET SPIGOT NON-PRESSURE PIPES

5.1 General

RCC NP3 and RCC NP4 class pipes shall be used as per the requirement. These pipes shall be in accordance with the specifications mentioned in IS:458-2003 and its Amendments. These proposed pipes shall be in accordance with the specifications mentioned in relevant IS and for which no extra cost other than the one which is mentioned in BOQ will be paid.

5.2 Materials

For pre-cast reinforced concrete pipes, materials complying with the requirements given in (i) to (v) shall be used.

a) Cement

Cement used in RCC NP3 pipe should be with Sulphate resistant cement and conforms to IS: 12330-1988

b) Aggregates

Aggregates used for the manufacture of reinforced concrete pipes shall conform to IS:383-1970. The maximum size of aggregate should not exceed one third the thickness of the pipe or 20 mm, whichever is smaller.

c) Reinforcement

Reinforcement used for the manufacture of the reinforced concrete pipes shall be mild steel Grade I or medium tensile steel bars conforming to IS: 432 (Part1):1982 or hard drawn steel wire conforming to IS: 432 (Part 2) or structural steel (standard quality) bars conforming to IC: 2062.

d) Concrete or Mortar

The quality and design mix requirements of concrete (concrete mix, maximum water-cement ratio, minimum cement content, etc) used for the manufacture of reinforced cement concrete pipes and collars shall conform to IS:456-2000 for at least very severe environment exposure condition and shall also be in accordance with Concrete and Allied works Section of Technical Specifications. In case of pipes cast by spinning process, higher cement contents, more fines and higher water-cement ratio may be the need of the process.

The concrete for non-pressure pipes shall have a minimum compressive strength of 35 N/mm2 at 28 days. If mortar is used, it shall have a minimum cement content of 450kg/m^3 and a compressive strength not less than 35 N/mm2 at 28 days.

Compressive strength tests shall be conducted on 15 cm cubes in accordance with the relevant requirements of IS:456-2000 and IS:516-1959.

The manufacturer shall give a certificate indicating the quantity of cement in the concrete mix.

i) Rubber Ring

Rubber ring chords used in pipe Joints shall conform to Type 2 of IS:5382-1985.Rubbers rings shall be tested and approved before usage.

5.3 Design

i. General

Reinforced concrete pipes either spun or vibrated cast shall be designed such that the maximum tensile stress in the circumferential steel due to specified hydrostatic test pressure does not exceed the limit of 125 N/mm^2 in the case of mild steel rods, 140 N/mm^2 in the case of hard-drawn steel wires and high strength deformed steel bars and wires.

The barrel thickness shall be such that under the specified hydrostatic test pressure, the maximum tensile stress in concrete, when considered as effective to take stress along with the tensile reinforcement shall not exceed 1.5 N/mm^2 for non-pressure pipes. The barrel wall thickness shall be as per IS:458-2003.

Longitudinal reinforcement shall be provided to ensure rigidity and correct location of cages (grids) longitudinally and to limit the effects of transverse cracking. Minimum longitudinal reinforcement shall be as given in respective tables of IS:458.

ii. Reinforcement

The reinforcement in the reinforced concrete pipe shall extend throughout the length of the pipe and shall be so designed that it may be readily placed and maintained to designed shape and in the proper position within the pipe mould during the manufacturing process. The circumferential and longitudinal reinforcement shall be adequate to satisfy the requirements specified under (i).

The pitch of circumferential reinforcement shall be not more than the following:

a) 200 mm for pipes of nominal internal diameter 80 to 150 mm,
b) 150 mm for pipes of nominal internal diameter 200 to 350 mm, and
c) 100 mm for pipes of nominal internal diameter 400 mm and above.

The pitch shall also be not less than the maximum size of aggregate plus the diameter of the reinforcement bar used.

The quantity and disposition of steel in pipes may be decided by mutual agreement between the BWSSB and the supplier; however, it shall be proved by calculations and tests that the quality of the pipes conforms to all the requirements specified in the standard. In the absence of calculations and tests, the reinforcement given in the respective tables of IS:458 shall be used as minimum reinforcement.

If so required by the BWSSB, the manufacturer shall give a certificate indicating the details relating to quality, quantity and dispersion of steel in the pipes as well as the clear cover to the steel provided in the pipe.

iii. Ends of Pipes

Dimensions of spigot and socket for rubber ring roll on jointed pipes shall be as given in the respective tables of IS:458. Reinforcement in socket of rubber ring jointed pipes shall be as given in the respective tables of IS:458-2003.

5.4 Manufacture

5.4.1 General

The methods of manufacture shall be such that the form and dimensions of the finished pipe are accurate within the limits specified in this standard. The surfaces and edges of the pipes shall be well defined and true, and their ends shall be square with the longitudinal axis.

ii) Concrete mixing

Concrete shall be mixed in a mechanical mixer. Mixing shall be continued until there is a uniform distribution of the materials and the mass is uniform in colour ad consistency, but in no case shall the mixing be done for less than two minutes. Water-cement ratio shall be less than 0.5.

The concrete shall be placed before setting has commenced. It should be ensured that the concrete is not dropped freely so as to cause segregation. The concrete shall be consolidated by spinning. Vibrating, spinning combined with vibrations, or other appropriate mechanical means.

iii) Reinforcement Cages

Reinforcement cages for pipes shall extend throughout the length of pipe barrel. The cages shall consist of spirals or rings and straight of hard-drawn steel wire or mild steel rod and may be circular. Circular cages and longitudinal reinforcement shall be placed symmetrically with respect to the thickness of the pipe wall. The spirals shall end in a complete ring at both the ends of a pipe.

Pipes having barrel thickness **above 100 mm** shall have double reinforcement cage and the amount of steel in the outer cage shall be 75% of the mass of the inner cage whilst the total shall conform to the requirements specified in the relevant tables of IS 458 : 2003. The total longitudinal steel per pipe shall be given in the relevant tables of the standard but the distribution shall be such that the round shape of the cage is not disturbed.

Diagonal reinforcement may be provided in pipes for which the cages are not welded so as to help in binding the cage securely. It shall, however, be ensured that the clear cover for any reinforcement is not below the limits specified in **6.4 of IS 458.** If diagonal reinforcement is provided, it shall be considered as part of process requirement and shall not be counted against the longitudinal reinforcement and spiral reinforcement. Single reinforcement cage shall be located near the inner surface of the pipe with adequate clear cover.

iv) Water Curing

Pipes manufactured in compliance with this standard shall be water cured for a period of not less than 2 weeks in case of pipes made from ordinary Portland Cement or Portland slag cement or Portland Pozzolana cement or hydrophobic Portland cement, and not less than 1 week in case of pipes made from rapid-hardening Portland cement or 53 grade ordinary Portland cement. Pipes may be water-saturated material or by a system of perforated pipes, mechanical sprinklers, porous hose, or by any other approved method that will keep the pipe moist during the specified curing period. In the case of large pipe projecting partly above the water level, the projected portion shall be kept wet by any suitable means.

5.5 Dimensions

The internal diameter, wall thickness, length of pipes, minimum reinforcements and strength test requirements for different classes of pipes shall be as specified in the respective tables of IS 458. The manufacturer shall inform the **BWSSB** of the effective length of spigot and socket that he is able to supply.

Tolerances

The following tolerances shall be permitted:

Sr. No.		Dimensions	Tolerances
i)		Overall Length	: ± 1% of Standard Length.
ii)		Internal Diameters of Pipes	
	a)	Up to end including 300mm	: ± 3 mm
	b)	Over 300mm and up to and including 600mm	: ± 5 mm
	c)	Over 600mm	: ± 10mm
iii)		Barrel Wall Thickness	
	d)	Up to end including 30mm	:+2mm − 1mm
	e)	Over 300mm and up to and including 50mm	: +3mm − 1.5mm
	f)	Over 50mm and up to and including 65mm	:+4mm − 2mm
	g)	Over 65mm and up to and including 80mm	: +5mm − 2.5mm
	h)	Over 80mm and up to and including 95mm	:+6mm − 3mm
	i)	Over 95mm	: +7mm − 3.5mm

Note:

In case of pipes with flexible rubber ring joints, the tolerance on thickness near the ends will have to be reduced. Near the rubber ring joints, the tolerance on thickness shall be as given in Tables 13 to 19 of IS:458.

5.6 Workmanship and finish

i) Finish

Pipes shall be straight and free from cracks except that craze cracks may be permitted. The ends of the pipes shall be square with their longitudinal axis so that when placed in a straight line in the trench, no opening between ends in contact shall exceed 3 mm in pipes up to 600 mm diameter (inclusive), and 6 mm in pipes larger than 600 mm diameter

The outside and inside surfaces of pipes shall be dense and hard and shall not be coated with cement wash. The inside surface of pipe shall be smooth. For better bond the inner surface of the collar may be finished rough.

The pipes shall be free from defects resulting from imperfect grading of the aggregate mixing or moulding.

Pipes shall be free from local dents or bulges greater than 3.0 mm in depth and dents and bulges shall not be extending over a length in any direction greater than twice the thickness of barrel.

Pipes may be repaired, if necessary, because of accidental injury during manufacture of handling and shall be accepted if in the opinion of the BWSSB, the repairs are sound and appropriately finished and cured, and the repaired pipe conforms to the requirements of this specification.

ii) Deviation from Straight

The deviation from straight in any pipe throughout its effective length, tested by means of a rigid straight edge as described in IS 3597 shall not exceed, for all diameters, 3 mm for every meter run.

5.7 Tests, sampling, inspection and marking

All RCC S/S Non-pressure pipes are to be tested, for the numbers/scale of sampling and inspected and clearly marked as per the relevant clauses (10, 11 and 12) in IS:458-2003.

5.8 Transport and handling of pipes and other materials

The specification for transport and handling of pipes shall conform to IS: 783-1985 unless otherwise specified.

a) The R.C.C. pipes, base plates, machinehole frames and covers, bolts and nuts, clamps etc., shall be transported by the contractor for laying and construction work at the respective sites of work at his own cost.

b) It is essential to transport, handle and lay the pipes, materials, etc in such a manner as not to cause damage. In lorry/truck shipments, the pipe shall be supported in wide cradles of suitably padded timbers hollowed out on the supporting surface to fit the curvature of pipe, and all chains, calves, or other equipment used for fastening the load shall be carefully padded. For smaller diameter pipes, sand or saw-dust filled bags may be used instead of hollowed out timbers. Pipes shall not be thrown down from the lorries/trucks nor shall that be dragged or rolled along hard surfaces. Slings of canvas or equally nonabrasive materials of suitable width or special attachment shaped to fit the pipe ends shall be used for lifting and lowering pipes so as to eliminate the risk of damage.

c) Great care shall be taken in handling the pipes right from the first operation until they are laid and jointed. The contractor shall be responsible for any loss or damage to the pipes and other materials.

5.9 Permission to lay pipe, concrete

When any portion of the excavation shall have been carried down to the necessary depth, the contractor shall obtain permission from the Engineer before commencing the laying of pipes or concrete.

5.10 Laying and jointing of sewers

a) The specification for laying and jointing of RCC pipes shall conform generally to IS:783-1985 and amendments thereon.

b) These specifications cover the work of laying all RCC pipe lines, underground and above ground, including all civil works required for the same.

c) The Contractor shall manufacture the pipes for a length of maximum 500 m at a time. All these pipes should not be conveyed to the site at a stretch, Contractor shall carefully convey and stack the pipes along the side of the road at every two machinehole lengths only. and this should not affect the traffic and pedestrians.

5.11 Laying and Jointing of R.C.C. pipes

a) Before commencing the work of pipe laying the contractor shall study the longitudinal section and other relevant details of the pipe line for the section/reach concerned. Pedestals/ cradles to be provided for shall be constructed before commencing the pipe laying work in any section, If the pipes are required to be wholly encased in concrete encasement of the pipes shall be done as per the method decided by the Engineer.

b) The contractor should check all pipes, rubber rings and other materials beforehand and satisfy himself and intimate, the department if any defects are noticed or if the quality is found to be not to standard.

c) All pipes shall be carefully handled and lowered into the trench by means of proper methods of handling. The pipes shall be handled by flat rubber belts.

d) Socket should face the opposite to the direction of flow. Pipe shall be normally laid so that spigot end enters the socket face. The socket and spigot ends of the pipe shall be cleared of all extraneous matter especially of clay and grease. Rubber ring shall be clean and dry.

e) All the pipes shall be laid perfectly true both in line and grade specified in the drawings. the rubber rings shall be kept evenly positioned on the spigot groove and when satisfied that the pipe and rubber ring are correctly positioned, the pipe shall be forced/pushed well right home of the full depth of the joint by means of uniformly applied pressure with the aid of a jack or similar appliance. The rubber ring shall conform to 1S:5382-1985. Inside the joint, the two pipe ends shall be in close proximity. Properly fitted temporary wooden stoppers shall be provided and constantly used to close the ends of all in completed pipe lines.

f) Bailing or pumping out of water from trench including shoring, strutting and removing slush while laying, jointing and testing shall be done by the contractor. Caving, sliding, under pinning, floatation are some of the features to be kept in view by the contractor and he shall take all required/necessary special precautions during the course of execution. The contractor shall see that water will not be allowed to accumulate in open trenches, where work is in an incomplete stage. Precautionary works such as blank-flanging the open ends of the pipe line shall be taken up at the contractor's account and no separate payment will be made for the same. Should any section of the pipe line float during the contract period, the entire cost of laying it again to the correct line and level shall be to the account of the contractor.

g) Blank flanges
Blank flanges shall be provided at all ends left unattended for the temporary closure of work. At the end of a day's work, also suitable closures shall invariably be provided at the open end or ends to protect the pipe line from ingress of sub-soil water, mud, muck, debris, dust etc.

h) Wherever pipe laying work is done from two faces and/or has to be done in broken stretches due to any difficulty met with at site, to carry out final connection, the contractor should take all special precautions such as maintaining the levels, grades, alignment keeping in view the length of pipes. If any mistake or error occurs, the contractor shall relay the entire stretch at his cost. Any losses or damages either to pipes

or other material thereupon shall be at the contractor's expense and necessary recoveries shall be made.

i) Precautions against floatation

When pipeline laid underground or above ground in a long narrow cutting gets submerged in water collected in the trench or cutting, it is subjected to an uplift pressure due to buoyancy and is likely to float, completely or partly empty. In the design of pipelines, provision is made to safeguard against floatation by providing sufficient overburden or by providing sufficient dead weight by means of anchor blocks.

In the case of the work extending into the monsoon season, however, special care and precautions are necessary during the progress of work on this account. The work of providing anchor blocks and refilling the trenches to the required level and compacting the same etc. shall always be done as soon as the pipeline has been laid.

The contractor shall see that water will not be allowed to accumulate in open trenches, where work is in an incomplete stage, precautionary work such as blank-flanging the open ends of the pipeline and filling the pipeline with water etc. shall be taken as directed by the Engineer. Such works shall be to the contractor's account and no separate payment will be made for the same. A two metres over burden shall be maintained at all times. Where this overburden is not available, anchor blocks have to be provided.

Protection of pipeline against floatation during the contract period shall be the responsibility of contractor. Should any section of the pipe line float due to their negligence etc, the entire cost of laying it again to the correct line and level shall be to his account.

5.12 Spigot and socket joint (flexible)

The RCC pipe with rubber ring accurately positioned on the spigot shall be pushed well home into the socket of the previously laid pipe by means of uniformly applied pressure with the aid of a jack or similar appliance. The RCC pipe shall be of spigot and socket type and rubber ring shall be used, and manufacturer’s instructions shall be deemed to form a part of these Employer’s Requirements. The rubber rings shall be lubricated before making the joint and the lubricant shall be soft soap water or an approved lubricant supplied by the manufacturer.

5.13 Cleaning of pipes

As soon as a stretch of RCC pipes has been laid complete from machinehole to machinehole or fora stretch as directed by Engineer, Contractor shall run through the pipes both backwards and forwards a double disc or solid or closed cylinder 75 mm less in diameter than the internal diameter of the pipes. The open end of an incomplete stretch of pipe line shall be securely closed as may be directed by the Engineer to prevent entry of mud or silt etc.

If as a result of the removal of any obstructions the Engineer considers that damages may have been caused to the pipe lines, he shall be entitled to order the stretch to be tested immediately. Should such test prove unsatisfactory, contractor shall amend the work and carry out such further tests as required by the Engineer.

It shall also be ascertained by the contractor that each stretch from machinehole to machinehole or the stretch as directed by Engineer is absolutely clear and without any obstruction by means of visual examination of the interior of the pipe line suitably enlightened by projected sunlight or otherwise.

5.14 Testing at work site

After laying and jointing of RCC pipes is completed the pipe line shall be tested at work site as per the following Employer's Requirements and as directed by the Engineer. All equipment for testing at work site shall be supplied and erected by contractor. Water for testing of pipes shall be arranged by him. Damage during testing shall be contractor's responsibility and shall be rectified by him to full satisfaction of the Engineer. Water used for the test shall be removed from pipes and not released to the excavated trenches. The details of testing are given in relevant clauses of IS:458-2003.

SECTION – 6

DOUBLE WALL CORRUGATED PIPES (DWC PIPES)

6.1 General

DWC pipes shall conform to IS 16098 (Part-2). The pipes shall be with non-smooth external and smooth internal surface based on PE structured wall piping system for non-pressure underground sewerage system.

DWC pipes are classified on ring stiffness and shall be designated in the following nominal ring stiffness classes (SN):

a) DN ≤ 500: SN 4, SN 8 or SN 16

b) DN >500: SN 2, SN 4, SN 8 or SN 16m

Under this contract, it is proposed to adopt Class SN8 ring stiffness as per IS 16098 (Part-2).

6.2 Composition of the material

The material from which the pipe is produced shall consist substantially of polyethylene (PE) or polypropylene (PP) to which may be added those additives that are needed to facilitate the manufacture of the pipes as per Tables 1, 2, 3 and 4 of IS 16098 (Part-2) and conforming to requirements of IS16098 (Part-2). In general, (i) base density shall be ≥ 0.930 g/cc in accordance with IS 7328 (ii) Melt flow rate (MFR) ≤ 1.6 g/10 min at 190 ^{0}C and 5 Kg loading mass and shall be as per IS 2530 (iii) Thermal stability (oxidation induction test at 200 ^{0}C)≥ 20 min.

6.3 Rework material

Clean, reprocess able material generated from a manufacturer's own production according to IS 16098 (Part-2) may be used if it is derived from the same raw material as used for the relevant production. Reprocess able material obtained from external sources and recyclable material shall not be used.

6.4 Wall construction designated as type B

Outside Profiled and Inside Smooth Profile Section: A pipe with a smooth internal and profiled external surface forming a finished double walled profile shall be confirming to IS 16098 (Part-2).

6.5 Dimension of pipes and fittings

Diameter of Pipe

The internal diameter (DN/ID) shall be as per Cl No. 6.3.1, Table 5 of IS 16098 (Part-2).

Length of Pipe

The effective length of pipe shall be not less than that specified in Cl No. 6.3.2 and as given in Fig. 2 of IS 16098 (Part-2).

Diameters of Pipes and Spigots of Pipes

The nominal sizes and minimum mean inside diameter for DN-ID series are specified in Cl No. 6.3.3, Table 5 of IS 16098 (Part-2).

The outside diameters of the DN-ID series pipes and spigots intended to have jointing dimensions as pipes according IS 16098 (Part-2) shall comply with the outside diameters and tolerances as specified by the manufacturer.

Diameters and Jointing Dimensions of Sockets and Spigots

Minimum requirement regarding the socket and spigot dimension are specified in Cl No 6.3.4, Table 5 of IS 16098 (Part-2) and Joints with the elastomeric sealing ring shall be positioned in the socket of pipes.

Wall Thickness of Spigot

When the spigot has the same design as the pipe, the wall thickness requirements for the corresponding pipe dimension and construction shall be as per Cl No. 6.3.5 of IS 16098 (Part-2).

Wall thickness of sockets & spigots and joint design requirements

In addition to the minimum required wall thickness of sockets and spigots as per Cl No. 6.3.5 of IS 16098-(Part-2), their ring stiffness, when determined in accordance with Table 10 of IS-16098 shall conform to the requirements of 6.3.5.1.1 of IS 16098 (Part-2).

6.6 Physical characteristics for pipes and fittings

Appearance

The structured outer layer of finished pipes shall be uniformly corrugated. The inner layer shall be smooth and plain. Both layers shall be free from any visual defects such as cracks, blisters, foreign inclusions and any other visual irregularities which may cause harm to its construction integrities. The inner surface may reflect slight shallow undulations and overall shall be as per Cl No.7.1 of IS 16098 (Part-2).

Colour of Finished Pipes

The inner and outer layer of pipes shall be coloured throughout. The outside layer of pipes and fittings should preferably be black, orange, brown or grey and overall shall be as per Cl No.7.1.1 of IS 16098 (Part-2).

Physical Characteristics

When tested in accordance with the test method specified in Table 6 (Physical Characteristics of PE Pipes) using the indicated parameters, the pipes shall have physical characteristics that conform to the requirements given in Table 6 of IS 16098 (Part 2).

6.7 Mechanical characteristics

Mechanical Characteristics of Pipes

The ring stiffness, Impact Strength, Ring flexibility and Creep ratio for the pipes when tested in accordance with the test method specified in Table 10 using the indicated parameters, pipe shall have mechanical characteristics conforming to the requirements given in Table 10 of IS 16098 (Part-2).

Joints

Elastomeric sealing rings used for joining of pipes shall be free from substances that can have a detrimental effect on the pipes. Elastomeric sealing rings shall be in accordance with one of the types (Type 1 to Type 6) of IS 5382 based on the manufacturer's recommendation. A test report or conformity certificate shall be provided from the manufacturer of the sealing ring for conformity to IS 5382.

6.8 Performance requirements

When tested in accordance with the test methods specified in Cl No.9, Table 12, for (i) Tightness of Elastomeric ring seal, (ii) water tightness, resistance to internal pressure, (iii) Resistance to combined temperature cycling and external loading and other parameters as per the Cl No.9 of Table 12, the joints and the system shall have characteristics conforming to the requirements given in Table 12 of IS 16098 (Part-2).

6.9 Sampling, frequency of tests and criteria for conformity

Acceptance Test

Acceptance tests are carried out on sample selected from a lot as per IS in accordance with Table 13 (for pipes) of IS 16098 (Part).

Type Test

Type testing shall be in accordance with Tables 15 of IS 16098 (Part-2), as applicable. All tests are required to be carried out either in an in-house laboratory or at an authorized third party laboratory.

Sampling Lot

All pipes of the same size, same grade and manufactured essentially under similar conditions shall constitute a lot. These pipes shall be selected at random from the lot and in order to ensure the randomness of selection, a random number table shall be used as per IS 4905.

In the absence of a random number table, the procedure given in Table 19 of IS 16098 (Part-2) may be adopted.

Conformance

The lot having satisfied dimensional and visual requirements shall be tested for other requirements with the sample size selected as per Table 20 of IS 16098 from the lot for conformance as per IS 16098(Part-2).

6.10 Marking

General Marking shall be labelled, printed or formed directly on the pipe, in such a way that after storage, weathering and handling the legibility shall be maintained.

Minimum Required Marking Pipes

Each pipe shall be marked at intervals of maximum 3 m, at least once per pipe, with the following information: a) Manufacturer's name/Trade-mark; b) Diameter series, nominal size; c) Stiffness class; d) Material; and e) Lot number/batch number containing information regarding period of manufacture (f) Name of the Client : BWSSB, Bengaluru.

BIS Certification Marking Each pipe shall also be marked with the Standard Mark.

6.11 Transportation, handling, installation and jointing

6.11.1 Transportation

The arrangement of loading the pipes in a telescopic manner is advised, that is, smaller diameters inserted into the next higher sizes of pipes up to the height of 2.5 m in a truck. While loading the pipes into the truck, care should be taken that the spigot/coupler end should be arranged alternatively in the corresponding layer so as to avoid the damage to the coupling/socket-end.

6.11.2 Handling

Following recommendations shall be followed while handling the pipes: a) Pipes shall be smoothly lowered to the ground. b) Pipes should not be dragged against the ground to avoid the damages to the coupler/ pipes. c) 900 mm and larger diameter pipes are carried with slings at two points spaced approximately at 3 m apart. d) For smaller diameters (450 mm to 900 mm, both exclusive) one lift point shall be sufficient. e) For diameters smaller than or equal to 450 mm, manual labour can be used. f) Loading boom or fork lift should not be used directly on or inside pipe.

6.11.3 Pipe Storage at Site

Stockpiling shall be done temporarily on a flat clear area as per IS 16098(Part-2). For avoiding collapse of stacks, wooden posts or blocks shall be used. Stacking shall not be higher than 2.5 m. While stacking, alternate the socket/coupler ends at each row of stacked pipes as per IS 16098 (Part-2).

6.12 Construction methods

6.12.1 Trench Preparation

Dimensions: The width of a sewer trench depends on the soil condition, type of side protection and the working space required at the bottom of trench for smooth installations. Increase in width over required minimum would unduly increase the load on pipe and cost of road restoration. Considering all above factors, the minimum trench width is specified as per Table 21 of IS 16098 (Part-2) and given below shall be adopted.

Minimum Trench Widths

(Clause A-4.1.1)

S. No.	Pipe Diameter (in mm)	Trench Width (in M)
1	75 to 200	0.6
2	250	0.7
3	300	0.8
4	400	0.9
5	600	1.2
6	800	1.3
7	900	1.6
8	1000	1.8
9	1200	2.0

6.12.2 Excavation:

Excavation of sewer trenches shall be in straight lines as much as possible and to the correct depths and gradients as specified in drawings.

Excavated spoils shall not be deposited in the near proximity to prevent the collapse of side of the trenches. The sides of the trench shall, however, be supported by shoring (where necessary) to ensure proper and speedy excavations and concurrently ensuring necessary protections to contiguous structures. In the event, the presence of ground water is likely to cause instability in soil conditions, sump pumping/a well point system/any other suitable dewatering system may be adopted for lowering of water table below the requisite trench bed level. If excavation is made deeper than necessary, the same shall be filled and compacted at the contractor's cost.

6.12.3 Shoring: mild steel sheet piling: As per the site requirement and as directed, the protective shoring works shall be strong enough to prevent caving in of trench walls or subsidence of contiguous areas adjacent to the trench.

6.12.4 Underground services:

The underground public and private utility services exposed due to the excavation shall be effectively supported under the guidance of the owners of such services.

6.12.5 Dewatering: Sewer installation trenches shall be adequately dewatered for the placement of pipe at proper gradient till the pipe is integrated through socket and spigot joint assembly with the already laid segment.

Precautions are to be taken to arrest floating of installed sewer segments against buoyant forces in case of sudden accumulation of water in the trench. The diameter wise minimum cover necessary to counteract the buoyant forces is given in Table 22.

For exceptional cases of higher level of ground water, additional anchoring at equal intervals would be necessary and shall be done as per the contract provisions.

6.12.6 Bedding: For maintenance of sewer slopes the initial backfill envelop with sand or gravel or as per site requirement and as directed would be sufficient. In the event, anchorage becomes imperative the transverse concrete anchorage blocks spaced at suitable interval shall also act as chairs for defining and maintaining the sewer slopes.

Laying:

a) Make the trench reasonably free from ground water and other liquids.

b) Place the pipe on the top level cross-struts of the timber shoring/mild steel sheet piling frame work.

c) Dismantle one/two cross struts and lower the pipes to the immediate lower layer of the cross struts and re-fix the struts immediately (in case of shoring for supporting the trench sides).

d) In the same above manner, reach up to the initial back filling and place the pipe at proper slope.

e) Ensure anchorage, if any, after laying.

Jointing: Various methods for jointing such as spigot and sockets are used.

The moulded socket will have a suitable internal surface with profiles ribs for insertion of the next pipe into it. The socket end of the pipe to be inserted will have corrugated outer layer. On first valley segment of corrugated pipe (destined to be pushed into the coupler socket) one elastomeric rubber ring needs to be placed which is pushed into the coupler socket. This provides sufficient gripping lock and leak proof joint.

For quality connections following steps are to be ensured, failing which the performance aspects will be severely compromised: a) The non-coupler-socket end needs to be clear and free from any foreign material. b) Use a clean rag or brush to lubricate the non-coupler socket end with lubricant. (c) Clean and lubricate the coupler end (spigot) of the pipe to be laid in similar manner. d) Lubricate the exposed gasket in the same manner with pipe lubricant. e) Keep the lubricated non-coupler end free from dirt, backfill material, and foreign matter so that the joint integrity is not compromised. f) Push the coupler/socket into non-coupler/spigot and align properly. Always push coupler end into non-coupler end. For smaller diameter pipes simple manual insertion shall be sufficient. In every methodology, it should be ensured that the coupler end is adequately ‘homed’ within non-coupler end to ensure installation and tight joining seal. Therefore, prior to insertion always place a homing mark on appropriate corrugation of the noncoupler end.

6.12.7 Construction of Backfill Envelope and Backfilling of the Trenches:

These pipes and well compacted backfill envelope work together to support soil and traffic load. In general, material used for construction of backfill envelop around the pipe comprises the following: a) Initial backfill; b) Side fill; and c) Top backfill.

The material for backfill envelop shall be as per the structural design of flexible buried conduit. It can be the same material that were removed in the course of excavation or it can be fine sand/course sand/gravel or as per site requirement and as directed. The remaining portion of backfilling shall be the materials that were removed in the course of excavation. These materials shall consist of clean earth and shall be free from large clod or stone above 75 mm, ashes, refuse and other injurious materials.

After completion of laying of pipes, etc, first the backfill envelope shall be constructed as per design around pipe. Voids must be eliminated by knifing under and around pipe or by some other technique and compacted with necessary watering, either by hand rammers or compactors to a possible maximum level of proctor density. Backfilling shall start only after ensuring the water tightness test of joints for the concerned sewer segments. However, partial filling may be done keeping the joints open. Precautions shall be taken against floatation as per the specified methodology and the minimum required cover.

6.13 List of approved makes

The naming of a manufacturer in this specification is not intended to eliminate competition or prohibit qualified manufacturers from offering Pipe/equipment. Rather, the intent is to establish a standard of excellence for the material used, and to indicate a principle of operation desired.

In order to achieve standardization for appearance, operation, maintenance and manufacturer's service, to the greatest extent possible, shall be the end products of one (1) manufacturer.

	Pipes	**Makes of Equipment**
	DWC Pipes	Prince Piping Systems, Mumbai.
		Gemini Pipes, Jaipur, Rajasthan, India
		Alom Poly Extrusions Ltd, Kolkata, West Bengal

Note-1: In the event that the contractor wishes to propose alternate vendor for the DWC pipes mentioned above, he shall submit the following during detailed engineering:

1) Demonstrate that the proposed makes are “Superior / Equivalent” to the approved makes.
2) Submit quality certificates that the Pipes/equipment adheres to the specifications as mentioned in this section.
3) Submit product brochures for the proposed equipment.
4) At least 10 successful individual installations/Sewer laying of similar size as per this contract.
5) Manufacturer to provide full contact information for each reference as part of technical bid.

SECTION-7

DUCTILE IRON PIPES (DI)

7.1 Manufacture of Pipe

DI pipes (Class K7 & K9) and fittings (Class K12) shall be in accordance with IS: 8329 and IS: 9523. Pipes and fittings shall be procured from reputed manufacturers with Engineer's approval. Engineer shall at all reasonable times have free access to the place where the pipes and fittings are manufactured for the purpose of examining and testing the pipes and fittings and for witnessing the test and manufacturing. For the gravity sewers DI pipes of class K7 shall be used and for the pumping mains DI K-9 Class pipes shall be used.

All tests specified either in this specification or in the relevant Indian Standards specified above shall be performed by the supplier/Contractor at his own cost and in presence of Engineer if desired. For this, sufficient notice before testing of the pipes and fittings shall be given to Engineer.

If the test is found unsatisfactory, Engineer may reject any or all pipes and fittings of that lot. The decision of Engineer in this matter shall be final and binding on the Contractor and not subject to any arbitration or appeal.

The pipes and fittings shall be stripped, with all precautions necessary to avoid warping or shrinking defects. The pipes and fittings shall be free from defects. Any defect in pipes and fittings in the opinion of Engineer shall be rejected and shall be replaced by new one.

In the case of spigot and socket pipes and fittings the socket shall be without the centre ring.

In the case of flanged pipes, the flanges shall be at the right angles to the axis of the pipe and machined on face. The bolt holes shall be drilled and located symmetrically off the centerline. The bolt hole shall be concentric with the bore and bolt holes equally spaced. The flanges shall be integrally cast with the pipes and fittings and the two flanges of the pipe shall be correctly aligned.

7.2 Materials

The materials used in the manufacture of pipes and fittings shall comply with requirements specified in IS: 8329 and IS: 9523.

7.3 Dimensions and tolerances

The internal diameter, thickness and length of barrel, dimensions of pipes and fittings shall be as per relevant tables of IS: 8329/IS: 9523 for different class of pipes and fittings. Each pipe shall be of uniform thickness throughout its length.

The tolerances for pipes and fittings regarding dimensions, mass, quality and deviations from straight line in case of pipes shall be as per IS: 8329/IS: 9523.

7.4 Testing of pipes during manufacture

(a) Mechanical Tests

Mechanical tests shall be carried out during manufacture of pipes and fittings as specified in IS: 8329 / IS: 9523. The frequency and sampling of tests for each batch of pipes shall be in accordance with IS: 8329. The test results so obtained for all the pipes and fittings of different

sizes shall be submitted to Engineer. The method for tensile tests and the minimum tensile strength requirement for pipes and fittings shall be as per IS: 8329/IS: 9523.

(b) Brinell Hardness Test

For checking the Brinell hardness, the test shall be carried out on the test ring or bars cut from the pipes used for the ring test and tensile test in accordance with IS: 1500. The test shall comply with the requirements specified in IS: 1500/IS: 8329.

(c) Retests

If any test piece representing a lot fails in the first instance, two additional tests shall be made on test pieces selected from two other pipes from the same lot. If both the test results satisfy the specified requirements, the lot shall be accepted. Should either of these additional test pieces fail to pass the test, the lot shall be liable for rejection.

(d) Hydrostatic Test

For hydrostatic test at works, the pipes and fittings shall be kept under test pressure as specified in IS: 8329 / IS: 9523 for a period of minimum 15 seconds, during which the pipes shall be struck moderately with a 700 g hammer for conformation of satisfactory sound. They shall withstand the pressure test without showing any leakage, sweating or other defect of any kind. The hydrostatic test shall be conducted before surface coating and lining.

7.5 Laying of the pipe

Laying of DI pipes shall conform to the Code of practice of IS: 12288. Pipes shall be laid underground with a minimum earth cover of 1m. Pipes shall be generally laid in sections of 300 m each. Laying of pipes shall be as per Standard Specifications for Procurement of Project Works. All pipes, fittings and material shall be tested and approved by the Engineer before being laid. Any pipes, fittings or material placed before they are tested and approved shall be removed and replaced with tested and approved material. Before laying the pipe, necessary bedding shall be provided wherever required. Polyethylene sleeves wounded pipes shall be used for water logged areas as per specification and as directed by the Engineer.

7.6 Jointing of pipes

(a) General

Jointing of DI pipes and fittings shall be done as per IS: 12288 and manufacturer's recommendations. After jointing, extraneous material, if any, shall be removed from the inside of the pipe. Rubber sealing rings/gaskets used for jointing shall conform to IS: 638, IS: 12820 and IS: 5382.

(b) Spigot and Socket joints

These shall have sockets, which are integral with the pipe and incorporate an elastomeric rubber ring gasket conforming to IS: 12820.

The gaskets/sealant used for joints shall be suitable for water conveyance. In jointing DI pipes and fittings, the Contractor shall take into account the manufacturer's recommendations as to the methods and equipment to be used in assembling the joints. In particular the Contractor shall ensure that the spigot end of the pipe to be jointed is smooth and has been properly

chamfered, so that the rubber ring as per IS: 12820 and IS: 5382 is correctly positioned in line, before the joint is made. The rubber rings and any recommended lubricant shall be obtained only through the pipe, supplier or as otherwise directed by the Engineer.

(c) Gaskets for Flanges

All gaskets used between flanges of pipes shall be of natural rubber conforming to IS: 638 of thickness 3 mm suitable for clear water conveyance and as specified by manufacturer.

(d) Flanged joints

These shall be of PN 1.0 rating and shall comply with dimensions and drilling details as specified in IS: 8329. These shall have isolation gaskets between the flanges, isolation sleeves around all bolts and isolation washers under all bolt heads and nuts. All material shall be supplied by a reputed manufacturer and shall be approved by the Engineer.

Each bolt should be tightened a little at a time taking care to tighten diametrically opposite bolts alternatively. The recommended bolting torque to be followed for assembling flanges shall be as specified in manufacturer's instructions. The practice of fully tightening the bolts one after another is highly undesirable. The bolts shall be of mild steel unless otherwise specified. They shall be coated with coal tar epoxy coating after tightening.

7.7 Coatings

(a) General

Unless otherwise specified, DI pipes and fittings shall be coated with Bitumen in accordance with relevant IS specifications. All buried DI pipes and fittings shall also have factory or site applied polythene sleeving. Coating shall not be applied to pipe and fittings unless its surface is clean, dry and free from rust. Pipe coatings shall be inspected at site and any damage or defective areas shall be made good to the satisfaction of the Engineer.

(b) Bitumen coating

Bitumen coating shall be of normal thickness of 75 microns unless otherwise specified. It shall be cold applied compound complying with the requirements of relevant Indian standards, suitable for tropical climates, factory applied in accordance with the manufacturer's instructions.

Damaged areas of coating shall be repainted on site after removing any remaining loose coating and wire brushing any rusted areas of pipe.

(c) Cement mortar lining

All pipes and fittings shall be internally lined with cement mortar in accordance with IS: 11906. Cement mortar lining shall be applied at the factory in conformance with the above-mentioned standards. The cement used shall be High Alumina Cement. No admixtures in the mortar shall be used without the approval of the Engineer.

Pipe linings shall be inspected on site and any damage or defective areas shall be made good to the satisfaction of the Engineer.

Lining shall be uniform in thickness all along the pipe. The minimum thickness of factory applied cement mortar lining shall be as per IS: 11906.

(d) Marking

Marking shall be done as per IS: 8329 and IS: 9523 or any other relevant IS codes.

7.8 Carting & handling

Pipes and fittings/specials shall be transported from the factory to the work sites at places along the alignment of pipeline as approved by Engineer in lengths not more than the length of the transporting vehicle. Contractor shall be responsible for the safety of pipes and fittings/specials in transit, loading/unloading. Every care shall be exercised in handling pipes and fittings/specials to avoid damage. While unloading, the pipes and fittings/specials shall not be thrown down from the truck on to hard surfaces. They should be unloaded on timber skids with steadying ropes and / or by any other approved means. Padding shall be provided between coated pipes, fittings/specials and timber skids to avoid damage to the coating. Suitable gaps between pipes should be left at intervals in order to permit access from one side to the other. As far as possible, pipes shall be unloaded on one side of the trench only. The pipes shall be checked for any visible damage (such as broken edges, cracking or spoiling of pipe) while unloading and shall be sorted out for replacement. Any pipe, which shows damage in the opinion of Engineer, shall be discarded and replaced by new one without extra cost. Dragging of pipes and fitting/specials along road or pipeline alignment shall be prohibited.

7.9 Methods of measurement for sewerage system

1. For manufacture, supply and delivery of pipes, measurement shall be taken for actual number of pipes multiplied by the standard length.
2. Laying and jointing of pipes and specials and valves will be measured in linear meters along the centre line of the pipes actually laid, jointed and tested and will be limited to the number of pipes x standard length + part length of pipe if any including specials and work is including the cost of rubber ring.

SECTION – 8

ACCEPTANCE TESTS

8.1 Check for Obstruction

a. As soon as a stretch of pipes whether of RCC Pipes or DWC or DI Pipes has been laid Complete from machinehole to machinehole , the Contractor shall run through the pipes both backwards and forwards a double disc or solid or closed cylinder 75 mm less in diameter than the internal diameter of the pipes. The open end of an incomplete stretch of pipe line shall be securely closed as may be directed by the Engineer to prevent entry of mud or silt etc.

b. If as a result of the removal of any obstruction the Engineer considers that damages may have been caused to the pipe lines, he shall be entitled to order the length to be retested at the expense of the Contractor. Should such retest prove unsatisfactory the Contractor shall at his own expense amend the work and carry out such further tests as are required by the Engineer.

c. It shall also be ascertained by the Contractors that each stretch from machinehole to machinehole is absolutely clear and without any obstruction by means of visual examination of the interior of the pipe line.

8.2 Hydraulic Testing of Sewers

Immediately after the test with the double disc or cylinder as mentioned above has been completed and any defects thereby disclosed have been made good, the Contractor shall prove the joints of the stretch of under-ground pipes are water tight.

Each section of sewer shall be tested for water tightness preferably between Machineholes. To prevent change in alignment and disturbance after the pipes have been laid, it is desirable to backfill the pipes up to the top keeping at least 90 cm length of the pipe open at the joints. However, this may not be feasible in the case of pipes of shorter length, such as stoneware and RCC pipes. With concrete encasement or concrete cradle, partial covering of the pipe is not necessary.

If it is necessary that the pipelines are filled with water before commissioning the application of pressure to allow for the absorption by pipe wall as per relevant IS standards.

The Sewers are tested by plugging the upper end with a provision for an air outlet pipe with stop cock. The water is filled through a funnel connected at the lower end provided with a plug. After the air has been expelled through tile air outlet, the stop cock is closed and water level in the funnel is raised to 1.5 m above the invert at the upper end. Water level in the funnel is noted after 30 minutes and the quantity of water required is measured at an interval of 10 minutes to restore the original water level in the funnel. The pipe line under pressure is then inspected while tile funnel is still in position. There shall not be any leaks in the pipe or the joints (small sweating on tile pipe surface is permitted), any sewer or part there of that does not meet the test shall be emptied and repaired or re-laid as required and tested again. The leakage or quantity of water to be supplied to maintain the test pressure during the period of 10 minutes shall not exceed 0.2 litres/mm dia, of pipes per kilometre length per day. Water and other accessories required for testing shall be to the account of the contractor. In case of DI pumping/rising mains the hydro testing of the pipes shall be carried out as per IS 8329 provisions.

8.3 Testing of Machineholes

The entire height of the machinehole shall be tested for water tightness by closing both the incoming and outgoing ends of the sewer and filling the machinehole with water. A drop in water level of not more than 50 mm per 24 hours shall be permitted. In case of high sub-soil water, it should be ensured that there is no leakage of ground water into the machinehole by observing the machinehole for 24 hours after emptying it.

Water and other accessories required for testing shall be arranged by the contractor at his own cost.

SECTION 9

TECHNICAL SPECIFICATIONS FOR TRENCHLESS TECHNOLOGY

9.1 General Specification

These specifications are intended for general description of quality and workmanship of materials and finished work. They are not intended to cover minute details. The work shall be executed in accordance with best modern practices and using appropriate techniques of trenchless technology as necessary considering the physical and geotechnical site conditions subject to approval of the Engineer.

The quantities specified in the tender are only approximate and may change depending upon the actual site conditions and the work by trenchless technology shall have to be carried out at quoted rates only.

Contractor's obligations

The scope of this component of the contract is ***"design and build"*** pipelines laid by trenchless technology works like pipe jacking/ pushing, auger boring or micro tunnelling and shall cover all equipment, designs, preparatory works, safety measures, testing and commissioning etc necessary for trenchless process. If the Contractor intends to use any other trenchless technique, it shall be with prior approval of the Engineer and at no extra cost of whatsoever nature to the Employer. The Contractor may request the Engineer for approval to a specific trenchless technique but Engineer's decision shall be final and binding. However, the Contractor shall be solely responsible for adequacy and safety of any of the techniques to be used. The Engineer reserves right to consider such alternative trenchless techniques.

The clauses in this section are meant to provide general guidelines and compliance requirements to the Contractor. It does not however relieve the Contractor from taking every other steps and precautions as deemed necessary to complete the installation of the pipelines successfully within the specified contract period and the amount.

The objective of the work is to provide and lay sewer lines meeting the hydraulic requirements for future and fulfilling the structural and serviceability requirements.

The Contractor's shall note that the alignment of the proposed works is in vicinity or affected by-

- Highways including existing CC road pavement and major junctions of roads
- Railroads including tracks on high embankments
- Crossing of major nalla/ drains/ water courses or in close vicinity of water bodies
- Laying of sewers in congested areas where traffic diversion is not permitted

Furthermore, the consideration that a method permitted as a suitable method of installing the sewers by trenchless technology shall not relieve the Contractor in any way from his prima facie obligation and responsibility under the contract to successfully install the pipelines without causing interruptions to traffic or inconveniencing citizens or road users and within the specified contract period and contract amount.

The Contractor's rates in the Bill of Quantities shall be deemed to be for installing the pipelines successfully including all appurtenant and/or ancillary works within the specified contract period regardless of the method.
It shall be obligatory for the Contractors to carry out geotechnical and other investigations including buried services detection by appropriate equipment and satisfy themselves and the Engineer of the adequacy of their testing.

The Employer / Engineer shall not be responsible for any changes in method or equipment necessitated during execution of the work and it shall be contractor's sole responsibility to ensure deployment of proper method and equipment for the work.

The Contractor shall, on his own accord collect information or conduct investigations about likely geotechnical conditions at the site. Any risks assumed by the applicant by solely depending on his current knowledge of the site of the information currently available on the geotechnical conditions, buried services, any physical obstructions shall be entirely his own and he shall be solely and fully responsible for any consequential expenses arising as a result of the risk he assumed. He shall not resort to any compensation claim under the contract for differing ground condition that he may encounter as a result of assuming the risk.

The extent and scope of the geotechnical and other investigations along the pipeline route would depend on the type of the equipment and systems that he proposes to use in the project.

The applicant shall ensure that the Trenchless Technology system shall successfully excavate in wide ranging ground conditions, from soft ground, sandy/ silty strata to hard rock strata or strata with boulder or high water table etc. likely to be encountered at the sites. For soft and slushy grounds the contractor shall adopt appropriate ground improvement method to suit the construction method as well as to ensure long term stability of pipeline laid during its lifespan.

Scope of Work

The scope of work under this component shall include but not be limited to the following :

a. Thorough geotechnical investigations needed for ground assessment and sewer laying using trenchless work.
b. Detection and mapping of buried services in vicinity of the proposed alignment and providing a diversion or relocation plan. Temporary diversion of such utilities in consultation with the concerned owners and the Engineer of the Contract shall be at risk and cost of the Contractor.
c. Arrange for permissions from various authorities including railways and pay necessary charges which shall be reimbursed by the Employer at actuals.
d. Construction of shafts/ insertion or access pits for the proposed method using appropriate excavation technology such as well sinking or sheet piling or trench box shoring or any other type of shoring system with detailed design including leaving any type of shoring system in trenches as necessary.
e. Design, manufacture and supply of appropriate type of pipes suitable for the technique to be adopted including RCC Jacking pipes conforming to JSWAS A-2/ A-6, HDPE pipes conforming to IS 14333, DWC pipes conforming to IS 16098 Part 1 and 2, MS pipes for manual pipe pushing/ jacking conforming to IS 3589as acceptable to the Engineer. The scope shall also include all types of carrier pipes besides the sleeve pipes.
f. Construction of Machineholes and appurtenances as per the specification requirements or as directed by the Engineer.
g. Planning, Detailed Design and construction of interconnection with existing system for connection of flows to the newly laid lines.

h. Excavation as necessary apart from construction of shafts
i. Backfilling of excavated trenches and reinstatement of surfaces
j. Rectification of any damage caused to adjoining structures
k. Management of excavated material including disposal of surplus material in environmentally friendly manner as directed
l. All ancillary and enabling works needed for the main works as mentioned above
m. Submission of as-built drawings (Soft copy and hard copies as required by the Engineer)

9.2 Selection of trenchless technique

The technique of trenchless technology to be adopted shall take in to account the physical site conditions, geotechnical conditions, arrangement of pipes, obligatory requirement of various authorities etc as mentioned below.

General approach for selection of trenchless technique shall be as under-

A. Application-
    a. Sewer line carrying domestic sewage
B. Function
    a. Gravity
C. Arrangement of pipes
    a. In casing- Casing + Carrier
    b. Direct carrier
D. Dimensional details
    a. Diameter (Jacking and Carrier)
    b. Depth of installation
    c. Obligatory length of single drive
    d. Limiting length of drive
E. Geotechnical aspects
    a. Soft ground (Clayey)
    b. Sandy/ silty
    c. Murum
    d. Soft/ Weathered rock
    e. Hard rock
F. Physical conditions
    a. Along a narrow road
    b. Along a wider road with heavy traffic
    c. Railway crossing
    d. Highway crossing/ Major Access Controlled Roads
    e. River/ Nalla/ Drains/ Water course crossing

G. Material of casing and carrier pipe
    a. RCC/DI
    b. HDPE/DWS
        i. Solid Wall
        ii. Double Wall
    c. MS
H. Arrangement desired
    a. Carrier and Sleeve
    b. Direct installation

The Engineer shall, in general, consider the above aspects for considering appropriate trenchless at a particular stretch of the work.

Trenchless techniques considered suitable are -

A. Pipe pushing/ Jacking
B. Auger boring
C. Micro tunneling
D. Any other method such as HDD

The Contractor may request for approval of the Engineer to any other technique but the Engineer's decision shall be final and binding on the Contractor.

9.3 Terminology and general description

Definitions

For the purpose of this contract document, the technical terms pertaining to micro tunnelling works and their functional details are defined below. The definitions herein are meant only as guidelines. If other (or new) definitions or technical terms are used by the Contractor in his submittals, they shall be clearly defined by him.

Micro tunnelling

Micro tunnelling is a process of accurately excavating, tunnels for installing underground pipelines, using steerable laser guided remote controlled shields of required diameters. Micro tunnelling permits accurate monitoring and adjusting of the alignment and level (either manually or automatically) as the excavation proceeds.
It is an art of accurately installing pipelines (usually 450mm diameter and above which may be up to 2400mm or even beyond), without digging up of ground surface, using a laser guided remote controlled shields for tunnel boring using slurry or EPB shields and pipe jacking technique for lining the bore with the product pipe.

The process of installing a pipeline by micro tunneling and pipe jacking system comprises five parts:-
(a) Micro tunnel boring machine (Shields)

(b) Automated spoil removal system
(c) Jacking system for pushing the jacking pipe and later on carrier pipe as needed
(d) Guidance system to guide the tunnel excavation
(e) Remote control system to operate the shield and other paraphernalia equipment.

Manual Pipe jacking

It is a process of lining an underground bore formed by manual excavation under a shield or other means and pushing specially designed jacking pipes (reinforced concrete or other pipes) simultaneously into the excavated tunnel bore, from a shaft (known as jacking shaft) to another shaft (known as receiving shaft).

Auger boring

Auger boring is a process of accurately excavating through ground using flights of augers for spoil removal and drill heads catering to various types of soils ranging from soft ground to rock for installing underground pipelines, using steerable guided remote controlled shields of required diameters generally 450mm to 1000mm. The method may involve pipe installation using single stage or multi stage operation using flight of augers and sections of the pipe to be installed.
A type of directional and guided boring machine, which uses auger flights to remove the spoil through separate casing placed through the product pipeline.
In this system, the excavated materials are continuously removed by an encased screw conveyor attachment connected to the rear of the tunnel cutter face. By controlling the speed of the screw augur and the outlet of the conveyor at the spoil discharge point, the excavated soil at the tunnel face can be kept under a desired balancing pressure to support the tunnel face.

Micro Tunnel Boring Machine (shield)

It is mechanized, steerable mini boring machine (or shield) equipped with suitable cutter head in front to excavate smaller diameter tunnels under controlled conditions in which the tunnel face and ground water pressure are continuously balanced as the shield excavates and moves forward. The operation and steering of the shield are remotely controlled with the aid of laser and/or CCTV system.
There are three systems available for the balancing the face pressure below:

Earth Pressure Balance (EPB) system

Earth Pressure Balance (EPB) is a system in which mechanical pressure is applied to the material at the face and controlled to provide the correct counterbalance to earth pressures in order to prevent heave or subsidence. The system allows excavation of the materials under controlled conditions so that no free flow of soil or ground water is permitted at the tunnel face. The spoil removal rate and the speed of the shield advancement are thus controlled either fully or semi-automatically.

Slurry Pressure Balance (SPB) system

It involves balancing the face pressure using a mechanical tunnelling shield with closed face, which employs hydraulic means for removing the excavated material, and balances the ground water pressure by mixing the excavated stuff with water to form slurry. In this system, the excavated materials is continuously mixed with water and or bentonite to convert into slurry and kept under a desired balancing pressure to support the tunnel face. The slurry is pumped to the ground surface where the solids are separated for disposal and the water is pumped back to the tunnel face for further utilization.

Automated spoil removal system

This system conveys the excavated spoil from the tunnel face to the ground surface for disposal. The spoil removal rate and the speed of the shield are fully or semi-automatically controlled in such a way to achieve minimal heave or settlement. The common systems available for the conveyance of the spoil and they are slurry system and augur system.

Slurry system employs hydraulic means for removing the excavated material by mixing the excavated stuff with water to form slurry. In this system, the excavated materials is continuously mixed with water and or bentonite to convert into slurry which is pumped to the slurry separation tank at ground level where solids can be separated from slurry and water reused.

In case of EPB shields, the removal of spoil is through a method which used balancing force of the excavated soil and the soil is generally removed using augers or belt conveyors.

Jacking System

The jacking system comprise high thrust hydraulic jacks mounted in a jacking frame capable of exerting the required jacking force against a purpose-built thrust wall to push the pipes and the shield forward through the ground. The jacking force is transferred evenly to the jacking pipe through a push ring connected to the pipe.

Guidance System

The guidance system comprises a laser beam device or a theodolite with laser beam attachment or visual guidance system such as CCTV. The device is installed in the jacking shaft and the beam is set to the desired level, gradient and alignment.

Some machines have photo sensitive cells on the target panel located at the rear of the shield which converts the laser position into digital data. The data are then electronically transmitted to the operator's control panel where digital readout of the location can be made. Some modern shields have built-in capabilities to use the digital data and automatically make necessary steering adjustments to guide the machine to the true alignment and level.

The contractor shall submit complete details of the guidance system he proposes to use and shall incorporate appropriate check points and hold points in the Quality Assurance Manual that he shall implement in the contract. The system shall provide continuous recording of the details of drive capturing various parameters not limited to the horizontal alignment or x & y coordinates, vertical alignment, roll, pitch, torque, jacking force, laser positions, jack positions, temperature of hydraulic system, slurry/ muck flow rates, etc. and a detailed printout of such parameters shall be submitted to the Engineer at the end of every day.
The laser source or theodolite shall be firmly supported in the jacking pit so that it is independent of any movement that may take place during the micro tunnelling and jacking operation.

Remote Control System

All micro tunnelling systems rely on remote-control capability. The control system monitors and controls the steering of the shield, spoil removal system (slurry or augur or vacuum), jacking system and guidance system. The system operation varies from totally manual to fully automatic. The remote control system is usually housed in portable control cabin.

The control cabin shall be located near to the jacking pit so that the operator can visually monitor the activities in the pit. Where it is not possible to locate the control cabin near to the pit due to space limitations, a CCTV camera system shall be set up in the pit to allow the operator to monitor the activities in the pit.

For the manual operating system, the operator's skill is very crucial for a successful completion of the project. The operator shall have experience of at least 10 years of piloting micro tunnelling equipment of which in driving.

The operator shall monitor all the information and continuously feed into the control panel as necessary. He shall be alert at all time and shall observe the crew's activities and other site activities, evaluate the information and make appropriate operational decisions. The information relayed back to the operator shall be audible, tactile and visual as The MTBM shall have facility to transmit sounds and vibrations from the excavation face to the operators to enable him to make appropriate operational decisions. Notwithstanding the ability of the equipment to keep automatic drive records, the operator shall monitor and keep record of line and grade of the machine, cutter head torque, thrust, RPM, steering pressures, slurry flow rate, pressures of slurry systems and rate of advancement.

In fully automated system, the machine acquires and evaluates the information and select the operational steps for automatic steering of MTBM. The information collected shall be logged in a microprocessor to obtain a printout as necessary.

The contractor shall incorporate check points and hold points for the guidance control system in the Quality Assurance System that he shall implement in the contract.

Supplementary systems

The supplementary system required for micro tunnelling and pipe jacking operation shall include Muck disposal system, pipe handling systems, pipe lubrication system, Grouting system, Guide rails, and Entrance and Exit rings and power supply systems.

Jacking shaft (or Jacking Pit)

Jacking Shaft is an important temporary structure from where jacking operation is performed. The shaft is usually rectangular or circular in shape and built using liner plates, sheet piles or timber shoring. The size of the shaft shall be such that it is capable of accommodating the jacking equipment (and also the shield), jacking pipe, thrust and entrance wall, Laser source and other paraphernalia or enable construction of machinehole or chamber as needed. This may correspond to the position of the Machineholes and the size and shape shall take cognizance of the same. The requirement for jacking shaft shall take full cognizance of the available working space and intended equipment. If it is intended to have a common shaft for both the drives, the size of shaft shall be selected accordingly.

Receiving shaft (Receiving pit)

A purpose-built temporary structure to receive and remove the tunnelling shield after its completion of a tunnel drive. The shaft is also rectangular or circular in shape and smaller than the jacking shaft. The size shall be sufficient enough to accommodate the tunnelling shield when it emerges into shaft after completion of a tunnel drive or construction of machinehole or chamber as needed.

Footprint

The footprint of a micro tunnel drive shall be taken as the net area occupied by the jacking or receiving shafts. The size of the footprint depends on many factors including the microtunnelling system and the length of jacking pipe used. The footprint requirement shall be an important factor, especially in congested and narrow roads when selecting the microtunnelling system for a project.

Thrust wall

Thrust wall is a temporary concrete or steel structure built within the jacking shaft to transfer the jacking force to the ground during jacking operation. The jacking shafts may often have more than a single thrust wall and each thrust wall shall be perpendicular and square to the pipeline to be jacked. The thrust walls shall be in good contact with the soils behind so that wall can transmit the jacking force effectively to the ground without affecting the shoring system.
All the affected thrust wall shall be demolished fully or partly after completion of jacking operation involving in that wall.

Entrance Ring

A steel flange fitted with a rubber seal (a 10mm to 20mm thick circular rubber gasket whose outside diameter is same as that of the steel flange and the inside diameter is smaller than that of the jacking pipe) installed perpendicular to the pipeline at the entrance. The purpose of the rubber seal is to prevent the slurry or ground water from entering into the shaft through the pipe entrance. The entrance seal shall be capable of withstanding anticipated pressure of the pressurized slurry with bentonite and/or the hydrostatic pressure

Exit Ring

This is similar to the entrance ring except that the internal diameter of the rubber seal is much smaller than that of the jacking pipe and is installed to prevent the slurry or ground water from escaping the tunnelling machine when it emerges at the receiving shaft. The exit seal shall be capable of withstanding anticipated pressure of the pressurized slurry with bentonite and/or the hydrostatic pressure.

Guide Rails (or Jacking Table or Frame)

To facilitate placing of the micro tunnelling machine and pipes in the jacking shaft, a set of guide rails are installed in position on the base of the shaft. The guide rail assembly (also known as jacking table/ frame) shall be carefully set up in the shaft to correct alignment and gradient so that the pipe when placed on it stays in line with and square to the pipeline alignment. The guide rail assembly shall be independent of the thrust wall so that it is not disturbed due to jacking force exerted onto the thrust wall.

Thrust Pressure Plate

The thrust pressure plate is usually a 50mm or 100mm thick steel plate installed between the jacks assembly and the thrust wall. The pressure plate enables the concentrated jacking load from the jacks to be transmitted evenly to the thrust wall,

Intermediate Jacking Station

For longer distance jacking, intermediate jacking stations, comprising a telescopic type jacking pipe assembly (usually made of steel), are used. A set of inter jacks and push ring are installed around the inner side of the female pipe of the telescopic pipe assembly. The intermediate jacking pipe assembly shall be installed at appropriate point and jacked-in along with the other jacking pipes. The contractor must plan for number of intermediate jacks as necessary for successful completion of the drive without overstressing the jacking pipes.

Cutter head (Micro tunnelling)

It is usually a disc shaped wheel mounted on the face of the micro tunnelling machine (shield) and is driven by hydraulic or electrical motor, located within the machine. The excavation capabilities of a micro tunnelling machine depend very much on the type of cutter head used, its speed of rotation and average and peak torque etc.

Different types of cutter head configuration are used in micro tunnelling machines to suit the type and nature of the ground through which tunnelling is to be carried out. For example, in soft ground tunnelling the cutter head shall have bits arranged in such a way to cleave and guide the soil into a chamber behind the cutter head through the openings provided in the cutter wheel.
In the case of rock or hard ground tunnelling the cutter head shall be equipped with suitable bits, roller bits or disc cutters for effective transfer of cutting energy to rock. In case of clay/ sand or mixed ground conditions, the cutter head shall be designed to suit the geotechnical conditions involving the site.

Cutter head (Auger boring)

In case of auger boring in rocky strata, the equipment shall be fitted with appropriate tools like “Front Steer” or “Pilot Tube System- RVS” or active and passive hole openers as necessary for successfully drilling in the anticipated ground.

Jacking Ring

Jacking ring or thrust plate is a purpose made structural fitting which shall be installed between the jacking assembly and the jacking pipe to transfer the point loads from the individual jacks into evenly distributed jacking force to the pipes being jacked. The ring shall be fabricated and machined, if necessary, so that it fits exactly onto end of the jacking pipe.

9.4 Performance Requirements

9.4.1 Design Life

For the purpose of designing the pipelines and the associated structures, the design life shall not be less than 60 years. The materials incorporated in the works and the workmanship shall be of required quality to sustain the specified life span.

9.4.2 Level and Alignment Accuracy

The pipes shall be installed into place, true to line and level. The maximum tolerance allowable in the displacement of the center line of the laid pipe from the design center line is 50 mm in the horizontal plane and 25mm in the vertical plane but there shall be no back-fall at any point.

There shall be provision to prevent the relative movement between pipes at the joints by the use of steel gaiters or other approved methods during jacking operation. A packing piece of compressible

material shall be provided at each joint and shall be securely held before the pipes are lowered into the thrust pit. Details of proposals shall be submitted to the Engineer for approval.

The Contractor shall be responsible for ensuring accuracy of pipe laying by micro tunnelling and shall take due cognizance of the ground conditions.

9.4.3 Limits on ground settlement and upheaval

The trenchless technology method adopted by the Contractor shall be such that the initial surface settlement measured directly above the front face of the shield or boring equipment during the tunnelling/ boring/ pipe jacking operations does not exceed 15mm and the maximum surface settlement after the tail voids are grouted shall not exceed 25mm. The affected ground and the structures shall be subsequently reinstated to their original condition at Contractor's risk and cost.

For the sections of pipeline crossing under nallas, roads and railways the Contractor shall be required to incorporate in his tunnelling method measures to arrest the expected settlements so as to safeguard the integrity of the road surfaces and collapse of nalla bed. The Contractor shall ensure that the traffic flow along the roads is not affected in any way as a consequence of his work.

In case of the works of laying sewers across any nallas or water courses, it may be necessary to provide kentledge to prevent upheaval or escape of slurry or to ensure proper overburden above the crown of the pipe being laid by microtunnelling. The contractor shall ensure that proper arrangements for non-disruption of the flow through such nalla or water course are made by adopting appropriate measures approved by the Engineer. Such kentledge in drains shall be removed and waterway cleared after completion of the work. No extra payment shall be admissible for provision and removal of such kentledge.

9.4.4 Providing temporary access to the jacking or receiving shafts

The alignment/ placement of Machineholes and shafts might have to be taken outside the carriageway in to kutcha portion.

Where it is seen that the locations of jacking and reception shafts do not have direct access from roads for taking construction plant equipment, the Contractor may have to provide temporary access including access over barges/ boats and also to erect marooned barges at the site of the reception shafts. Any temporary arrangement shall be subsequently removed, and the site conditions restored to their original state upon completion of the work.

9.4.5 Limitation on Footprint and weight of machine

The Contractor shall be deemed to have visited the sites and carefully planned and located the shafts at convenient points so as to minimize the working area to be occupied by the footprint. The contractor shall be deemed to have allowed for such site constraints and measures required, including working in the night and construction of decking over the shafts, provision of access roads for construction plant and machinery, to allow the traffic to flow, in his rates. He shall take the site constraints and restrictions into consideration when selecting the trenchless technology system. It is necessary to pay close attention to the ground conditions, bearing capacity of the ground at appropriate level and select the head and equipment accordingly. The weight of the equipment selected should be such as to eliminate equipment settlement during driving the tunnel and installation the pipes.

9.5 Contractor's submittals

9.5.1 General information on submittals

To ensure compliance with the requirements specified in the Contract, the contractor shall make a number of submittals as described in the following clauses to the Engineer for approval by the specified time. The contractor shall ensure that the submittals prepared are of good professional standard, comply with all the requirements specified in the contract and complete with all details and information to enable the Engineer to evaluate and approve the submission. It shall be clearly understood by the contractor that he shall not commence any work without the approval of the submittals by the Engineer.

Submittals by the contractor shall, include:

- Contractor's method of construction
- Microtunnelling equipment description and literature
- Jacking system and maximum jacking loads
- Pipe designs and shop drawings and calculation demonstrating the ability to sustain maximum jacking loads
- Intermediate jacking stations details
- Lubrication system
- Bentonite injection system details
- Ground water control details
- Entry and exit details
- Jacking and receiving shaft design details
- Thrust block details
- Muck removal and disposal
- Buried services details
- Detection equipment or any other trenchless technology system equipment etc.

All submittals shall be submitted by the Contractor in accordance with schedule mentioned.

9.5.2 Submittal on Contractor's method of construction- Microtunnelling including construction of shafts

The submittal shall contain a detailed explanation of various steps involved in the construction process. They shall include details of the equipment, specific manufacturer's instructions and guidelines pertaining to the project, a methodology statement outlining the operation of the equipment and, details of materials including pipe materials, rubber ring, and compressible packers and jointing of pipes.

The submittal shall also include construction details of other permanent and temporary structures such as jacking and receiving shafts, cast in-situ and precast Machineholes, or brick masonry Machineholes, thrust walls, and entry and exit of the shaft. The details of other equipment such as intermediate jacking stations, spoil removal system including slurry and feed pumps, control systems, slurry tanks and associated machinery, jacking frames, spacers, thrust ring etc., shall also be included in the submittal.

9.5.3 Submittal on geotechnical profile and geotechnical reports along the pipeline route

The Contractor shall establish the subsurface ground conditions and their range of variability along the pipeline before embarking on the works. He shall clearly identify the types of soil or rock that is likely to be encountered during boring or tunnelling along the entire pipeline alignment. If found necessary,

he shall carryout simple probing techniques. (Geophysical soundings or Seismic refraction method and soil resistivity tests)

He shall prepare a comprehensive geotechnical profile along the pipeline route with detailed descriptions of the types of soil or rock to be expected during boring/ tunnelling.
The Contractor shall endeavour to carry out essential geotechnical investigations and tests (Field as well as laboratory) immediately after award of the work for enabling him to select appropriate equipment/ methods. The Contractor shall be solely responsible for geotechnical investigations and the inference drawn from such investigations as well as the adequacy of the equipment and method adopted by him. However, other progress of works like construction of shafts etc. may be continued simultaneously.

9.5.4 Submittal on jacking pipe design and carrier pipes

The contractor's attention is drawn to the requirement pertaining to the design, manufacture and handling of the jacking pipes. The jacking pipes shall be manufactured in accordance with JSWAS A2 or BS 5911 Part 120 or equivalent standard approved by the Engineer. At the same time the pipes shall meet the test requirements for NP4 pipes under IS 458.

The Contractor shall with the approval of the Engineer, engage a reputable pipe manufacturer to design and manufacture the jacking pipes. The submittal shall include the manufacturer's name, address, contact telephone and facsimile numbers and the manufacturer's quality assurance /control and testing plan for the jacking pipe.

The manufacturer's representative's name shall be also included in the submittal. A dimensioned drawing of the jacking pipe with design calculations from the manufacturer shall be also submitted to the Engineer for approval.

The submittal for jacking pipes shall include particulars of the pipe moulds, casting facility, QA/ QC for pipes, anti-corrosive protection to the pipe. The submittal shall be accompanied with a letter from the plant owner giving guarantee for delivery of the pipes in accordance with the schedule of work as planned by the contractors and as directed by the Engineer / Employer.

The Contractor shall furnish a Memorandum of Understanding between the RCC pipe manufacturer and the Contractor for supply of Jacking Pipes and also an undertaking from the pipe manufacturer that they possess a valid BIS license and have supplied at least 500m of jacking pipes of 1000mm and above which have been successfully installed by micro tunnelling anywhere in India.

In case MS jacking pipes are considered necessary as sleeve pipes as a requirement of contractor's methodology for micro tunnelling and pipe jacking, the same shall be at no extra cost to the Employer.

The MS sleeve pipes in such case shall be of appropriate size to accommodate carrier pipe of required ID and shall conform to IS 3589 and shall be coated with anticorrosive coating as per the IS code requirements. In such cases RCC carrier pipes conforming to IS 458 or HDPE pipes conforming to IS 14333 or IS 16098 Part 1 or 2 shall be installed inside the sleeve pipes.

9.5.5 Submittal on microtunnelling/ pipe jacking/ auger boring system

The bidder / Contractor shall furnish name of the micro tunnelling/ auger boring system, model, manufacturer's technical literature for the equipment and all other data along with their bid. Any amendments deemed necessary by the Contractors shall be submitted along with the geotechnical profile within 21 days of submission of geotechnical profile to the Engineer. The submittal shall

include information to ensure that the micro tunneling/ auger boring equipment proposed for the project meet with the general requirements specified in these specifications and also the anticipated geological conditions. The submittal shall also include a certification from the manufacturer of the equipment about adequacy in the anticipated geotechnical conditions as also design calculations showing maximum anticipated jacking or pullback force and torque needed for tunnelling/ boring. The details shall also provide information of rock cutting tools or heads, spoil removal methods, guidance systems, jacking system and capacities, interjack systems, hole lubrication systems etc.

9.5.6 Submittal on site layout

Contractor's attention is drawn to various clauses in the document about the site constraints and space availability in all the sites. The contractor shall carefully examine the site and prepare site layout plans showing extent of work site, the arrangement of various ancillary equipment required for works, such as approaches for equipment, spoil removal equipment and slurry tanks, bentonite systems/ mud recycling system, generators, control cabin, tracking facilities, crane, storage of pipes etc for each drive and submit them progressively to Engineer for approval.

9.5.7 Submittal on existing pipe network details, ground and invert levels, location of shafts and new pipeline alignment

The contractor shall survey and verify the as-built invert levels of the upstream and downstream pipelines and Machineholes shown on the contract drawings for all the sites. The contractor shall confirm or insert the correct as-built levels in the contract drawings and submit them to the Engineer for necessary amendments and re issue of the contract drawings for construction. Under no circumstances the contractor shall commence works without verifying the as-built levels and obtaining the approval of the Engineer.

The Contractor will be required to set out and plan the actual placement of the alignment for the pipe laying well in advance of actual excavations. Trial holes/ probing and other preliminary surveys must be carried out and the resulting information carefully plotted.

For convenience of construction, if the Contractor prefers changes to the pipeline alignment or the location of Machineholes, he shall submit such changes to the Engineer for prior approval. The Engineer would evaluate and approve if the proposed changes are found to be economically and technically, and functionally acceptable. It shall be clearly understood by the Contractor that any construction risks and additional costs arising as a result of Contractor's changes made to the original pipeline design shall be entirely borne by the Contractor.

9.5.8 Submittal on jacking and receiving shaft design

The Contractor shall submit the design and construction details of the jacking and receiving shaft and their proposed locations along the pipeline route to the Engineer for approval. The Contractor's design shall ensure that the shaft dimensions are absolute minimum required and method of construction shall be such that the shafts are constructed without causing unacceptable obstruction to the existing traffic flow in the vicinity of the construction. The minimum size of the shaft shall, however, permit construction of appropriate machinehole / valve chambers as per the requirements. The Contractors shall also submit design and construction details of decking, if required, for the shaft. The Contractor shall be deemed to have allowed for in his Bid for such decking work necessary to maintain the traffic flow.

The submittal shall also include details on shoring system, entry and exit arrangement, thrust wall layout and design details, general layout of guide rail and jacking table arrangement etc.

In case the shafts are to be constructed by method of well sinking, the contractor shall provide complete design details along with method of sinking, soil removal, dewatering, concrete steining, kentledge arrangement etc. for approval of the engineer.

In case of shafts in the form of RCC wells, branch connections to the Machineholes constructed inside the well shall be provided at no extra cost to the Employer.

9.5.9 Submittals for obtaining approval from authorities

The Contractor shall submit separate schedule for obtaining approval of various authorities and obtain specific permission or approval through the engineer.

9.5.10 Submittal on buried services and obstructions

The Contractors shall investigate and determine the actual location of the buried or over the ground services (Metallic and non-metallic) and physical obstructions, if any, along the pipeline route and at his chosen locations of the jacking and receiving shafts, and submit service location drawings to the authorities responsible for electricity, telecom, water, pipeline, gas etc and obtain their approval or permission to excavate in their vicinity. The contractor shall use a good quality Ground Penetration Radar (GPR) for this purpose and shall submit complete details of the equipment and procedures for field investigations and laboratory/ desk analysis of the data captured in field.

The Contractor shall not interfere with the operation of any existing or proposed service. He shall carefully plan the pipeline route and the locations of the shafts and Machineholes and shall identify the services that require diversion well ahead so as to give ample time to the authorities to divert the services or give approval to carry out the diversion by others. Where applicable, the Engineer would assist the contractors in getting the approval as expeditiously as possible from authorities.

If in the opinion of the Engineer any services that are within the machinehole proper or affecting the alignment and require permanent diversion, they shall be diverted at the expenses of the Corporation. Expenses for all other diversions and temporary protection of services shall be borne by the Contractor.

Any consequential delays or expenditure arising from Contractors' carelessness or lack of foresight on this matter shall be entirely borne by the Contractor.
The Contractor shall fully co-operate with the Engineer and the authorities and shall have no claim for delay due to such relocation of services.

The Contractor shall allow for sufficient time for getting the permissions from the authorities.

9.5.11 Submittal on monitoring of ground settlement and upheaval

The Contractor shall monitor ground movement daily at the start of jacking operation and end of the jacking operation on that day and submit in an approved format the settlement or upheaval caused by the micro tunnelling and pipe jacking works to the Engineer.

It shall be incumbent upon the contractor to measure ground movements along the route of pipeline laid for a width of at least 5m or 2 times the depth of the pipe being laid on either side of the center line using appropriate equipment such as seismographs, accelerometers during construction and measure them at least once in six months during the defect liability period and in case any settlement of ground or pipeline is observed, the contractor shall take remedial measures at his risk and cost.

The contractor shall also conduct a joint survey of structures in vicinity to monitor any cracks or signs of distress and take timely remedial measures at his risk and cost.

9.5.12 Submittal on Safety

The Contractor shall be solely responsible for safety of the workmen, Engineer's staff and third party. The contractor shall implement a comprehensive safety plan for his work people and Engineer's/ Employer's staff or Third party. He shall comply with all relevant acts governing safety on construction site. He shall submit to the Engineer the details of the arrangements he made with the fire brigade, local health authorities and the availability of medical staff, first aid equipment ambulance, sick bay etc. He shall give the names and contact telephone numbers (24 hours) of the occupational health and safety personnel. Beside he shall submit a list of safety equipment that he would provide to all the workers on site. The Contractor shall appoint a Safety Officer or Safety Engineer at all times who shall be the responsible person for all safety related matters pertaining to the contract. Name of such person shall be communicated along with the submittals on safety. The contractor shall comply with the guidelines issued by any competent authority regarding safety at work site especially safety of persons working inside any pipeline- new or functioning. This shall be consistent with the contractor's obligations under the GCC/ SCC.

9.5.13 Submittal on quality assurance/control plan

The Contractor shall implement a Quality Assurance Program approved by the Engineer for the manufacture of jacking pipe and for actual installation of the pipes trenchless method on site. The Quality Assurance Programme shall be maintained in accordance with the provision of the manual. No works shall commence until the Quality Assurance Manual has been approved by the Engineer.

The Contractor's Quality Assurance System shall incorporate but not be limited to the following:
(i) The Quality Assurance and Quality Control procedures covering all materials, design, manufacture, supply and installation carried out by the Contractor and any of his sub-contractors and pipe manufacturers.
(ii) Such tests necessary to demonstrate that materials comply with the requirements of this specification and the requirements of the relevant Standards and Codes.
(iii) Contemporary records to be maintained pertaining to progress of the work.
The QAP shall mention check points and hold points and must be scrupulously followed.
The Contractor must be ISO 9001-2015 certified organization and must submit the Quality Manual for implementation during execution of the works.

9.5.14 Submittal on Contractor's personnel

The Contractor shall note that the skill of MTBM operator and their assistants is crucial for successful execution of work. The contractor shall submit complete information for the operators proposed to be

employed for the work. At least one MTBM operator must have an experience in operating MTBM in India.

The Contractor shall be required to deploy the key staff as committed during the bidding process. No change in the personnel shall be permitted subsequently without written approval of the Engineer. He shall submit the diagram showing the communication link within the site to Contractor's Head Quarters along with designation and telephone numbers of key staff for the Engineer's record. The Engineer reserves his right to reject any person who he thinks not suitable for the contract and the Contractor shall be obliged to replace such person immediately.

9.5.15 Submittal on remedial measures to be adopted by the Contractor

The Contractor shall take each and every precaution to ensure that the tunnelling or drilling equipment will successfully excavate along the chosen pipeline alignment before he commences the operation. Once the tunnelling/ drilling is commenced in a drive, the Contractor will be held fully and wholly responsible for the successful completion of the tunnel excavation and retrieval of the shield from the receiving shaft or for completion of pilot bore and hole enlargement upon back-reaming. In the event of inability to complete the drive, due to break down or any other reasons, the Contractor shall be fully responsible to recover the equipment safely from the ground and restore the incomplete work to the original condition at his risk and cost by a method approved by the Engineer and the concerned authorities within time stipulated by the Engineer or the concerned authority.

It shall be clearly understood by the Contractor that the occurrence of such an event is preventable as such an occurrence is generally due to Contractor’s negligence in the “preventive maintenance” of the equipment or driving of it to true level and gradient or his failure to determine accurately the expected ground conditions before commencement of the excavation.

The Contractor shall in his submittal clearly state the measures that he would implement to retrieve the shield without causing interruptions to railway, highway or road traffic etc., and without causing any damage to the property. The cost for such retrieval measures or any consequential expenditure or delays arising from thereof shall be entirely borne by the Contractor. Any failure to remedial measures shall be entirely at the risk and cost of the Contractor.

Any abandoned hole or tunnel must be grouted completely at the Contractor’s cost so as to prevent subsequent settlement.

9.5.16 Submission on work schedule

Notwithstanding the obligations of the contractor under the GCC, the contractor shall submit a detailed work schedule with suitable milestone events. The work schedule shall also take cognizance of the monsoon season, water levels and their fluctuations in the reservoir and their impact on ability to carry out the work etc.
A baseline schedule shall be submitted along with the bid which shall be frozen within 15 days of award of the work to successful bidder.

9.5.17 Effect of Approval and Acceptance of Proposals

Approval or acceptance by the Engineer of any proposal for executing the Works, including drawings, specifications or resources employed under the Contract shall not relieve the Contractor of his

responsibility for any errors thereon and shall not be regarded as an assumption of risk or liability by the Corporation. The Contractor shall have no claim under the Contract on account of the failure or partial failure or inefficiency of any plan, method of work or equipment approved or accepted by the Engineer. Such approval or acceptance shall be considered to mean only that the Engineer had no objection to these proposals.

Notwithstanding any approval or acceptance by the Engineer, the Contractor shall remain fully responsible for completing the Works correct in every detail.

9.5.18 Schedule of submittals

Below is a general schedule of submittals pertaining to trenchless works by the contractors

Sr. No	**Description**	**Schedule of submission**
1	Contractor's method of construction.	Along with the bid.
2.	Geotechnical profile along pipeline route.	Within 30 days of date of commencement letter.
3.	Jacking pipe design	Along with the bid.
4.	Micro tunnelling system.	Original submission along with the bid and any changes necessitated by the geotech investigation shall be submitted within 15 days of submission of geotech profile.
5.	Site layout	Within 45 days of commencement dates.
6.	Proposed Intaek Location and shafts and new pipeline alignment.	Within 45 days of commencement dates.
7.	Jacking & Receiving shaft design.	Along with the bid. Any changes necessitated by the geotech investigation shall be submitted within 15 days of submission of geotech profile.
8.	Approval from authorities.	Within 90 days of commencement date
9.	Obstructions.	Within 45 days of commencement letter
10.	Monitoring of Ground settlement & up level.	Along with the bid.
11.	Safety.	Along with the bid.
12.	Quality assurance/Central plan.	Along with the bid.
13.	Contractors Personnel	Along with the bid.
14.	Remedial measures.	Along with the bid.
15	Work schedule	Along with the bid

9.6 Products

9.6.1 Standards and Codes

Except as otherwise stipulated in this Specification, all materials and workmanship shall comply in all respects with requirements of such standard and specifications, codes and other standards issued by the Bureau of Indian Standards (BIS) and current at the date of bid as may be applicable to any part of the

Works of this Contract. In the event there being no relevant Indian Standard Specification, other relevant standard, specification, current at the date of bidding such as the British Standards Institution (BS), American Society for Testing Materials (ASTM), German Standards (DIN), Japanese Standard for Water and Sewerage (JSWAS), and/ or of the or any other equivalent standard approved by the Engineer shall apply. If after the date of invitation to Bid there is an amendment to a standard specification relevant to the Contract, the Engineer will direct whether the amendment is to apply.

In the event of there being any conflict between this Specification, the Drawings and any Standard Specification forming part of this Contract, this Specification shall take precedence over the drawing, codes and other standards in that order of precedence. In any case, the Engineer's decision shall be final and binding on the Contractor.

9.6.2 Selection of Equipment

The contractors shall be responsible for the selection of a suitable micro tunnel boring machine capable of excavating the materials including soft marine clay with high water table, rocks and mixed ground that may be encountered along the route of the pipeline to be laid under the contract.

The Contractor shall be solely responsible for ensuring that geological and geotechnical information he obtains or possesses for the sites is adequate to accurately determine the types of soil that may be encountered during execution of the project. The contractor is deemed to have carried out sufficient geological and geotechnical investigation of the sites and testing of the soil as necessary at his own cost before the selection of the micro tunnelling system.

Contractor shall be responsible for selecting suitable equipment for trenchless installation of the sewers capable of excavating all soil types which may be countered during the execution of the project.

The contractor shall also ensure that the system he selects for the project shall successfully excavate in the wide-ranging ground conditions from clayey and sandy strata to mixed ground/ hard rock that may be encountered along the route.

Contractors shall pay particular attention, when selecting the tunnelling/ boring equipment for the project, to ground water level fluctuation and the subsurface soil strata from marine clays, sands, gravels, soft soils that may be present at the sites. The equipment selected for the project shall have appropriate cutter head equipped with suitable cutter bits to excavate all types of soil formations below the water table.

The tunnelling/ boring equipment shall be capable of balancing the ground water pressure supporting the excavated tunnel face at all times. The equipment shall be articulated to enable remotely controlled steering, in both the horizontal and vertical directions. It shall be capable of preventing rotation and rolling movement of shield's body during the drive. The tunnelling/ boring equipment shall, have the following features.

(a) Equipped with suitable steering and guidance system that ensures easy steering control (With arrangement for anti-roll, or pitching/ dipping)
(b) Equipped with a suitable lubricating system arrangement
(c) Ability to provide for an Intermediate Jacking Station, as needed
(d) Instrumentation to measure deviation from the designed level and grade, rolling and pitching of the equipment, cutter torque and its percentage to the maximum torque, rpm, jacking speed, tunnel face pressure etc. preferably with a computerized data logging and printing facility.

(e) Spoil removal system (Slurry/ Auger system) capable of removal of excavated stuff by balancing the face pressure.

(f) The machine hall be manufactured by a reputed manufacturer having supplied at least one such machines during last five years in India and the supplied machines must have successfully carried out underground pipe installation work for a length of at least 500m.

The equipment proposed for the project shall meet the above-mentioned criteria failing which it will not be permitted to be used in the project.

9.6.3 Jacking Pipes (RCC/ MS)

The pipes must be manufactured in a reputed pipe manufacturing facility using vertical vibration casting method having valid BIS license for manufacturing of RCC pipes from450mm to 1400mm (NP3/ NP4 Class) under IS 458.

Pipes manufactured by the contractor's themselves in a temporary manufacturing facility shall not be acceptable.
The pipes for jacking operation shall be precast reinforced concrete pipes manufactured by vertical vibration casting process only.

Design, manufacture and factory testing of the pipes and specials shall be to BS 5911 Part 120 or JSWAS A-2-1973 or other acceptable standard and shall meet the test requirement specified in I.S 458 (NP 4 Class) or its equivalent standard as amended up to-date. The grade of concrete shall not be less than M45 design mix. The clear cover of concrete over steel reinforcement on the wet side shall not be less than 25mm.

The jacking pipes shall be provided with Stainless Steel Collars fixed to the female end of the jacking pipe.
Each pipe shall be provided with a precision cut compressible packer to be attached to pipe end with approved adhesive. The Contractor shall also provide details of the compressible packer including its dimensions, Modulus of elasticity etc.

The outside and inside diameters of the pipe shall be such that they match the dimensions of the tunnelling equipment or vice versa. The standard length of the pipe shall be 2.5m (Between 2.43m to 3.05m). However, the length of the pipe shall be shortened if desired by the contractor to suit the site conditions subject to the Engineer's approval.

The concrete used for jacking pipes shall be from a RMC plant. If the concrete for manufacturing pipes is produced at the plant itself, it shall be manufactured in an approved automatic batching plant. Complete details of the Batch of ready mix concrete like its Grade, WC ratio, maximum aggregate size, time of leaving the RMC plant, time of pouring into the moulds, additives and suppliers certificate shall be maintained for each batch. Three cube samples shall be taken from each RMC batch and tested for 28 days strength in a laboratory approved by the Engineer. If the test cubes fail the requirement, the finished pipe shall be liable for outright rejection after NDT (Schmidt Hammer Test or any other as directed by the Engineer).

The Engineer's representative shall have full authority to inspect any material or finished product and reject the same if not found conforming to the standards. The Contractors shall make his representative available to the Engineer's representative during such inspections and testing failing which the Engineers representative shall be at liberty to take ex-parte decision, which shall become binding upon the Contractor.

The pre-cast reinforced concrete pipes shall be sufficiently reinforced with steel to withstand all stresses induced by handling, jacking, earth and water pressures and all working loads at the depths at which they are to be used without cracking, spalling or distortion. The pipes shall be of at least strength Class NP4. A load factor (for the maximum jacking force) of not less than 2.0 shall be used in the calculations to determine the strength of the pipes required. The strength of the pipes shall be tested by the three-edge bearing test. When subjected to the design load in such a test, the load required to produce the crack width of 0.25mm on the pipe shall be in accordance with IS Code 458. All such tests shall be carried out at the expense of the Contractor. The frequency of the Three Edge Bearing test shall be at least once in 3 months or every 100 pipes or part thereof for each diameter.
When designing the jacking pipes, the contractor shall take into consideration jacking load including eccentric loading, pipe stiffness, corrosion resistance, flexibility, durability, joint efficiency etc.

The Contractor shall take precautions to minimize the resultant pipe stresses in a jacking pipe and to achieve a trouble free jacking operation. The eccentric loading shall account for maximum steer ability.

The Contractor shall submit full details of his proposals for the pipes, giving detailed drawings showing sizes, reinforcement and type of joints, calculations, together with the name of the proposed manufacturer, the place of manufacture and the manufacturing process to the Engineer for approval along with a consent letter from manufacturer of the pipes from such manufacture as well as the RMC supplier.

A detailed record (signed jointly by the Contractor's and Engineer's Representative) of concrete batch, its 7 day and 28 day strength, weight of reinforcement cage, weight and dimensions of the collar etc. shall be maintained for every pipe manufactured for use in the works.

Every pipe tested for the three Edge Bearing Strength shall also be tested for ultimate (crushing) test in presence of the representative of the Employer or PMC and/ or Third Party Inspection Agency. The pipe to be tested for three edge bearing test shall be randomly selected by the Engineer or any designated agency. At least one pipe in 200 pipes for each diameter must be tested for three edge bearing test outside the manufacturer's factory in a test facility as directed by the Employer. The test set up and the gauges shall be properly calibrated with a certificate from an agency authorized to do the calibration of equipment. The pipes shall meet the requirements of the Standards for Jacking pipes like JSWAS/ BS or any other acceptable standard but the requirements of strength and other tests like hydraulic and permeability shall be in accordance with IS 458.

All workmanship and materials used in the manufacture shall be subject to the approval of the Engineer who shall be authorized to inspect materials at source and the manufacturing processes in the factory at any time.

Proper curing arrangement in the form of water spray curing, steam curing or chemical curing as approved by the Engineer shall be provided.

(a) Pipe shall be straight and uniform with square ends. The joints shall be well formed to allow efficient transfer of jacking load from pipe to pipe

(b) Pipe joint shall be fitted with compressible packer for better distribution of jacking load.

(c) The jacking frame, jacks and steering head shall be properly aligned along the designed alignment and grade and the whole assembly shall be square and at right angles to the thrust wall
Steering corrections shall be made gradually to minimize abrupt misalignment angles between the pipes

The pipes should be provided with well-formed arrangement for groove for rubber gasket.
The pipes shall be internally lined with "T" rib type HDPE sheet lining as corrosion barrier (2 to 3mm thick) installed while casting of the concrete pipe.

The pipes shall be sufficiently cured (Minimum 28 days if wet cured with water spray or as approved by the Engineer is cured with steam or by application of chemicals) before they are dispatched to the works sites and used in the jacking process. They shall be handled with extreme care to prevent the edges of the pipes from chipping. The pipes shall be stacked in shade or adequately protected from severe sunrays. The Engineer may reject any pipes he considers not suitable for the Works and these rejected pipes shall be removed from the site immediately. After factory testing and before dispatch, every pipe and special shall be marked in accordance with the Standard used. In addition, each pipe shall be marked with a number corresponding with the order of manufacture and date of manufacture and Grade of Concrete. Test certificates from the manufacturers or other relevant authority shall be submitted to the Engineer.

The pipe manufacturing and testing process shall also be subject to Third Party Inspection. Pipes shall not leave the manufacturer's facility unless they are released by the TP agency/ PMC/ the Employer.
The sites may have limited or restricted storage space for stacking of jacking pipes. The Contractor shall therefore schedule the supply of pipes to the sites in such a way that only absolute minimum numbers of pipes are brought to the site at a time.

In case of MS jacking pipes, the pipes shall be manufactured and tested in compliance with IS 3589 and shall be provided with liquid epoxy coating/ lining system as per ANNEX B of IS 3589.
Carrier pipes shall comply with the relevant IS Standards.

9.6.4 Pipe Joints (RCC and MS)

The jointing arrangement for the jacking pipes is crucial in terms water-tightness, flexibility and smooth transmission of jacking force. Spigot ended jacking pipe with recess to receive rubber rings and stainless steel/ Mild Steel couplings (collars) or other acceptable joints shall be used in pipe-jacking application. The spigot and socket joints shall be flush from outside as well. The contractor shall submit joint details to the Engineer for approval.

The joint rubber rings supplied and installed shall be of the Cornelius rubber ring type or similar approved and shall be capable of accommodating 2 degree deflection at each joint. Joint rings shall meet with the latest edition of I.S 5328 and B.S 2494 part 2 or be of approved quality by the Engineer.
The properties of the joint ring shall be between those specified in BS 2494 for grade D and grade B.
The testing of rubber ring shall conform to IS. 3400 and also IS. 5382.

The Contractor shall indicate the grade of rubber rings he intends to use and submit samples for approval prior to incorporation in the Works. The grade, type or source of supply of rubber rings shall not be changed without the written approval of the Engineer.
MS pipes shall be with welded joints as per IS 5822

9.6.5 Pipe Couplings (Collars for RCC jacking pipes)

The pipes shall be provided with **Stainless Steel (SS 304 Grade) Collars.** The arrangement shall be of such dimension and thickness so that when inserted into the pipe, it fits exactly into the recesses in the pipe. The joint so formed shall be watertight. The joint details shall be approved by the Engineer. The thickness of collar shall not be less than 8mm.

9.6.6 Compressible packers

Appropriate compressible packers shall be used at the joints for distributing the jacking force evenly through the wall of the jacking pipes. Uneven transfer of jacking force from a pipe to another shall result in concentrated and excessive stresses in the pipe which can cause the pipe to crack. Contractor shall submit details of the compressible packers for Engineers approval.

9.7 Identification of pipes, rubber rings etc.,

Every pipe made shall be clearly and indelibly marked upon it unique identification number, class, batch of concrete, diameter and date of manufacture. (Suggested format: FACT_NAME /DDMMYYYY/Mxx/BATCH_NO/ NNN) Every finished pipe shall be tested for dimensional conformity and non-destructive testing with Schmidt Hammer or any other method as approved by the Engineer. Full records are to be maintained of each pipe test and for each individual pipe the date manufactured, cleared after testing and supplied on site.

The Contractor shall make arrangements for visits of the Engineer's representatives for inspection and 3 EB testing as and when deemed necessary by the Engineer. All expenses in connection with such visits shall be borne by the Contractors. After the satisfactory completion of testing and approval of the pipes by the Engineer the pipes shall be stored at factory premises during the period awaiting delivery.

No pipe shall leave the manufacturer's yard for the site unless it is tested and cleared by the Engineer's representative and the Third Party Inspection agency appointed by the Engineer/ PMC.

9.8 Tests on Jacking Pipes

Factory Tests

One pipe out of every 100 pipes or part thereof manufactured for each diameter shall be tested for Three Edge Bearing Test in the factory or a laboratory or institution approved by the Engineer at the Contractor's expense. Besides this at least one pipe in every 200 pipes shall be tested outside the factory in a facility as directed by the Engineer. The pipe for testing at a test facility outside the manufacturer's factory shall be selected at random from the pipes delivered at site. All expenses in connection with transportation to and fro, loading/ unloading, ant taxes/ fees etc shall be borne by the contractor.

Every RCC jacking pipe shall be subjected to following dimensional conformity tests and the tolerance shall be within limits as indicated below -

1. **Length**

Pipe Dia in mm	Tolerance for all types of pipes in mm
Above 1200	+25

2. **Perpendicularity of faces**

Pipe Dia in mm	RC Jacking pipe

Above 1200	8

3. Deviation from straight

Pipe Dia in mm	Tolerance for all types of pipes in mm
Above 1000	±10

4. Deviation from pipe d

Pipe Dia in mm	Tolerance for all types of pipes in mm
Above 1000	+0, -16

9.9 Execution

9.9.1 Information for the execution of works

The works under the scope of trenchless technology shall have to be carried out using approved trenchless technique.

The Contractor shall be responsible for inspecting the sites and familiarizing himself with the conditions under which the work will be performed and with all necessary details including geotechnical conditions and buried services as well as the physical conditions, tidal impacts etc. as to the orderly and successful execution of the work. The omission of any details shall not relieve the Contractor of full responsibility for the satisfactory installation of the work in its entirety. No monetary or other claims made by the Contractor on the grounds of want of knowledge will be entertained by the Engineer.

Plans and details of the equipment, materials and the method of construction to perform and complete the work shall be submitted by the Contractor for approval of the Engineer before commencing these operations. Approval by the Engineer shall not relieve the Contractor of his sole responsibility for the efficiency, reliability, and soundness of the method employed in completing the work in a satisfactory manner.

The Contractor is advised that it shall be his sole responsibility to ascertain for himself the extent of work that is required to be done in site and to generally obtain his own information on all matters affecting the execution of the whole of the works involved in this contract to the entire satisfaction of the Engineer. No claim of extras in consequence of any alleged ignorance in any aspect will be entertained by the Engineer. It must be clearly and definitely understood that the contractor shall be held solely responsible for making all necessary arrangements and coordinating with all relevant Authorities, Specialists, Sub Contractors, etc., to ensure satisfactory and timely completion of this contract.

9.9.2 Execution of works-General

The Contractor shall be fully responsible for the design and construction of the jacking/ launching and receiving pits, thrust wall, installation of jacking equipment, installation of any other equipment, sheeting/ shoring, bracing, etc., and for the efficient execution of the work.

The Contractor shall be required to monitor closely the progress of the trenchless operations. Daily manual logs or site records of thrusting pressures, torque, bentonite injection rate and the line and level measurements shall be properly maintained in addition to any computerized data logging and shall be available to the Engineer's representative at all times. Such records shall be duly signed by the Contractor's site in-charge. If the Contractor fails to maintain and produce such details before the Engineer's representative on site, the Engineer's representative may order suitable steps including suspension of the work without prejudice to any other rights of the Engineer. The Contractor shall be solely responsible for such actions ordered by the Engineer's representative.
It is the responsibility of the Contractor to ensure that the completed pipelines are watertight. If leakage occurs before completion or during the maintenance period, the Contractor shall carry out any remedial work that may be necessary to make the Works watertight all at his own expense.

9.9.3 Location and verification of buried services

The Contractor will be held solely responsible for making his own investigations of any buried services in the vicinity of the Works and to protect them from getting damaged due to his work. Contractor shall be deemed to have allowed for any extra costs in his rates for detecting all obstructions and buried services including appropriate measures to protect the services and temporarily divert the same in consultation with the concerned agency with its prior approval regardless of whether they are indicated on the drawings or not. It shall be the Contractor's responsibility to obtain any permission from such agencies. The Engineer/ Employer may issue necessary recommendation letters to the concerned utility agencies if required.

The contractor shall engage at his own cost a competent service detecting professional or agency who shall have state-of -the -art detecting equipment to locate and verify all the buried services such as pipeline, water, telecom, electricity, gas and all other services, and abandoned services and structures well ahead of commencing the works.

The detector shall be able to receive narrow signal responses from metallic or non-metallic buried services in order to pinpoint the position and direction of the services. It shall also be able to pick up the position and direction of different services in congested area and detect the buried services regardless of almost any environmental interference.

Combination of Ground Probing Radar (GPR) and Electromagnetic Location (EML) testing shall be used for locating the underground utilities and buried objects. The lines tested using GPR and anomalies located using EML shall be topographically surveyed using a Total Station / Theodolite at the same time as the geophysical testing is carried out.

The information so collected shall be submitted to the Engineer after getting it confirmed from the respective agency. It shall be clearly understood by the Contractor that no work shall be carried out without locating all the buried services and he will be held solely responsible for any consequential expenses and delays if he ignores this specific requirement or fails to locate any services along the route.

The Contractor shall take every precaution that in the opinion of the Engineer and as advised by the owner of the utility is necessary for the protection from injury of all existing and proposed water, drain, pipeline and other pipes, electric and telephone conduits, and other existing works, roads and services wherever encountered or which are adjacent to the works, and to maintain the same until in the opinion of the Engineer the general progress of the work renders further protection unnecessary. All damage occasioned by the Contractor to these works and services shall be repaired at once at the Contractor's risk and cost, as directed by and to the satisfaction of the Engineer.

9.9.4 Site investigation

The Contractor's site investigation for trenchless works in general shall be critical and the most important engineering work to be carried out before commencement of work on site. The contractor shall clearly understand the importance of establishing the subsurface ground conditions and their range of variability along the pipeline route well before embarking on the actual works. There should not be any room for unforeseen ground conditions and it is absolutely necessary for the Contractor to know what is to be encountered during the tunneling operation. The contractor shall be deemed to have accurately established the types of soil and rock strata along the tunnel bore and their range to enable him to select the equipment / machines and to set-up and operate correctly.

9.9.5 Subsurface investigation

The subsurface investigation shall include study of all existing geological and geotechnical information for the area including the information pertaining to the project and the location maps of all the services in the area from the utility companies/authorities for initial planning. Data on abandoned and existing obstruction, foundation, piles and the structures in the vicinity of the alignment shall be also collected. Field survey using utility services locator and trial trenches may also be carried out to verify the location of the services and obstructions.

Mapping out of the subsurface soils/rock profile along the pipeline alignment and locating underground utilities and buried objects by geophysical testing. Investigations may include documentary survey; bore logs, geophysical investigations, in situ & laboratory soil / rock tests. Various geophysical investigations include but not limited to Ground Probe Radar (reflection of electromagnetic waves), Radio Magnetotellurgy (measurement of resistivity in electromagnetic field of a radio transmitter), Electrical Method (measurement of apparent resistivity by injection of direct current and measurement of potential difference), Seismic Refraction (refraction of seismic waves on layers at speed increasing with depth), Seismic Reflection (reflection of seismic waves on contrasting interfaces), Microgravimetry. (local variation in gravitational field to detect cavities)

The Contractor is deemed to have allowed for any extra costs in his rates and to be aware of similar state of the art ground probing/mapping technology currently available on the market and to have made provision for its use in the project as part of his subsurface investigation works.

The contractor shall be deemed to have in possession of all the information and data required to accurately evaluate the subsurface conditions before commencement of any works.

9.9.6 Geological and geotechnical evaluation

The Contractor is deemed to have obtained, studied and evaluated all the geological and geotechnical data for the sites including any data if available with the corporation for the sites and made his own judgment and conclusion on the types of soils and rock to be excavated along the pipeline route. The Contractor must supplement this information possessed by him with appropriate geotechnical investigation prior to selection of appropriate micro tunnelling/ drilling machinery upon award of the work.

The applicant shall inform him thoroughly and make his own deductions as to the nature of the materials to be excavated; the difficulties of making and maintaining the required excavations and of doing other work affected by the geology of the Site and shall accept full responsibility thereof.
The Contractor shall carry out exploratory boreholes as deemed necessary by him and conduct laboratory testing as necessary for a micro tunnelling project. This information shall be supplemented

with tests such as soil resistivity tests and seismic refraction test to provide complete information about the stratigraphy in connection with the proposed works.

It shall be obligatory for the contractor to prepare a geotechnical profile along the alignment showing the proposed sewer line superimposed thereon to indicate strata anticipated. The contractor shall also detect and plot the buried services on the topographic survey map indicating their position in plan as well as approximate depth below GL.

However, this does not absolve the contractor from his responsibilities for successful completion of the work.

9.9.7 Bore logs and ground probing

Sufficient numbers of boreholes shall be taken by the Contractor. The Contractor should submit Geotechnical profile along the route of the pipeline and buried services data for the entire alignment per the schedule for submittals.

Continuous sampling shall be resorted to over at least 2xDia above the crown of the pipe and 2x Dia below invert of the pipe to be laid.

The Contractor shall collect soil/ rock samples at the level of the proposed pipeline in presence of the Engineer's represent and get the same tested for sieve analysis, cohesion, angle of internal friction, ground water level, Unconfined Compressive Strength (UCS), abrasivity etc. at any laboratory approved by the Engineer. Samples taken in absence of the Engineer's representative and tested in a laboratory not approved by the Engineer shall not be valid for determination of the any parameters.

9.9.8 Groundwater investigation

Ground water condition is one of the critical data required when selecting the trenchless technology system. Ground water affects the safety of the excavation face, start and exits of the tunnelling/ drilling equipment from the shafts. Uncontrolled extraction of water from the surrounding during excavation can affect the adjacent structures. Piezo-metric pressure, water leakage, ground water level and etc., shall be carefully checked before and during microtunnelling/ drilling/ boring works.

9.9.9 Ground stabilization/ improvement

It shall be the responsibility of the Contractor to maintain stable soil conditions at the jacking face to prevent loss of ground above the jacking operation and movement of the surrounding earth or to prevent diving of the machine and sinking of pipes. The methods of maintaining face stability and preventing ground movement and subsidence shall be by means of fluid slurry or earth pressure applied to the tunnel face. Alternatively, unstable ground ahead of the jacking face may be stabilized by the injection of suitable chemicals. Methods which require dewatering of the ground will not be accepted, nor will methods which may lead to significant ground loss.

Movement or settlement of structures, utilities and pavement shall be monitored by the Contractor during the trenchless operation and reported to the Engineer and concerned authorities.

The Contractor shall make provision to install peizometers, settlement plate etc., in his rates for pipe installation if movement or settlement occurs, which in the opinion of the Engineers may cause damage, the Contractor shall take immediate action to prevent further movement, settlement or damage. The Contractor shall repair at his risk and cost any damage and restore structures, and

pavements to the satisfaction of the Engineer. The contractor shall pay expenses if the owner or concerned agency or any Third Party elects to carry out such repairs by themselves.

9.9.10 Setting out

The Contractor shall be deemed to have thoroughly examined the sites, the location of the buried services, availability of space for footprint, access to sites & etc., and adjusted the pipeline alignment as deemed necessary and obtained approval of the final pipeline alignment from the Engineer before commencement of the setting out. He shall set out and mark on the ground the proposed pipeline route and the locations of the jacking and receiving shaft and the area they occupy for the Engineer's inspection and approval.

The Contractor shall be solely responsible for the accuracy of the setting out and any expenses or delays arising from errors made in the setting out shall be borne by the Contractor. Any consequential work or abortive work carried out by the Contractor to rectify the errors shall be entirely borne by the Contractor.

9.9.11 Site layout

The working space at the sites is often restricted and hence the site layout has to be planned carefully in advance to set-up the equipment and accessories.

9.9.12 Construction of Jacking and Receiving Shaft

The excavations for Jacking or Receiving shafts may be used for construction of Machineholes inside them provided proper branch connections as directed by the Engineer are cut in the wells sunk for shaft. The Contractor shall submit to the Engineer for approval dimensioned drawings and calculations of the timbering or trench sheeting details for the shafts. Each shaft shall have a separate ladder bay for access which shall be isolated from the part of the shaft used for hoisting materials. The shaft trenching shall be watertight and shall prevent any pressurized slurry from the tunnel face reaching the shaft.

Soil improvement methods that can be used include grouting, ground freezing, and dewatering. If the ground consists of unstable soil, the same may be stabilized by vibro / dynamic compaction, by compressed air for sandy soils and by ground freezing, preloading, lime treatment for clayey soils. In certain instances, ground treatment or groundwater management methods may be required to enable the construction of the shaft to proceed. These include well pointing and deep wells, Compressed air, Suspension grouts, Chemical stabilization, Ground freezing.

There are various shaft construction method alternatives, Liner plates, 2-flange steel liner, horizontal metal sheeting, sloping or battered excavation, trench boxes, slide railing system, soldier piles with timber lagging, soldier piles with steel lagging, steel / concrete / RCC sheet piles, CMP shafts, concrete sinking shafts, precast concrete segments, concrete slurry walls, Pre-cast or cast in- situ caissons, Rock anchorage rods and tensioned rock bolts, metal straps, un-tensioned steel dowels, Wire mesh with guniting and ground freezing. No extra payment shall be claimed by the contractors for carrying out soil improvement / stabilization, or shaft shoring techniques as mentioned.
The Contractor shall submit the design and construction details of all Temporary Shafts and their proposed locations along the tunnel alignment to the Engineer for acceptance. The submission shall also include details on shoring system, entry and exit arrangement, thrust wall layout and design details, general layout of guide rail and jacking table arrangement etc. Temporary Shaft drawings are to include but not limited to:

1. Launch/jacking and reception shaft configurations.

2. Design and construction of launch/jacking and reception shaft.
3. Details for excavation and backfilling procedures, ground support systems, and ground stabilization if required.
4. Special requirements for jacking and receiving shaft penetrations, thrust blocks, backstops or other reactions required for Microtunnelling/ pipe jacking/ auger boring, casing pipe jacking or any other jacking.
5. Full calculations supporting maximum jacking capacity that jacking shafts will withstand
6. Dewatering and ground water control plans for all temporary and permanent shafts.

The shaft shall be kept dry at all times and shall have a drainage sump to pump out the ingress water. The Contractor is deemed to be fully aware of the serious consequences to the tunneling equipment and other accessories if the shaft is flooded. He shall take every precaution to avoid flooding in the shaft the shaft shall be well protected against surface runoff getting into the shaft. The contractor shall be solely responsible for any consequential delays and expenditure arising as a result flooding the shaft.

The shaft floor shall be designed to withstand the tunnel machine and other accessories.
The Contractor shall be solely responsible for providing and subsequent removal of shoring to the shafts or pits and ensuring stability of the sides of such excavations and safety of adjoining structures.
The sizes of the shafts shall be kept as small as possible considering site constraints. Equipment manufacturer's data on required shaft sizes shall be furnished to the Engineer along with the bid. The sizes of pits shall take due cognizance of available space needed for jacking frame, shoring or feed pumps or other ancillary equipment, thrust wall and entrance ring.

Considering the ground and physical conditions at site, the shafts may be constructed using well sinking method as preferred method. The contractor shall be solely responsible for design, erection and maintenance of the caisson shafts constructed by him using well sinking.

9.9.13 Construction of Thrust Wall

Thrust wall shall be designed and constructed by the contractor to the approved details. The thrust wall shall be reinforced or unreinforced concrete constructed against the wall of the jacking shaft. The Contractor shall ensure that the thrust wall is constructed as an independent structure and it shall not interfere with the jacking shaft or the floor when jacking force is applied on to it. Contractor shall indicate in his submittals the construction details of the thrust wall showing details on how the wall be made independent of the jacking shaft structure.

The Contractor shall ensure that the thrust wall and the soil behind are in complete contact and there is no gap between them. The contractor shall further ensure that the thrust wall shall effectively transfer the jacking force on to the soil behind and that the ground behind is capable of withstanding the jacking force.

In the event that there is gap between the thrust wall and the soil behind, the Contractor shall arrange the gap to be filled with approved cement grout before loading the thrust wall.

9.9.14 Installation of Guide Rails/ Jacking frame

The Contractor shall design and fabricate the guide rail / Jacking frame in accordance with the equipment manufacturer's details and install it firmly onto the floor of the jacking shaft. He shall ensure that the guide rail / jacking frame is installed to the correct grade, levels and alignment. It shall be also square to the pipeline alignment at all times and not disturbed due to forces arising from the jacking operation. He shall arrange with the Engineer's representative to check the level, alignment

etc., of the guide rail and obtain the Engineer's endorsement before commencing guide the pipe jacking work.

9.9.15 Entrance and Exit Arrangement

One of the most critical operations is the launching and retrieval (entry and exit) of the micro tunnelling/ boring machine. Often this process takes place well below the water table. In those cases, it is critical that the contractor implement adequate engineering measures including improvement of unstable soil by grouting or other means to prevent soil and water inflows into the shaft.

It is common practice to install a rubber seal at the entry and exit. The seal is to prevent the flow of ground water or lubricant (used for reducing the frictional resistance) through the shield/pipe entry opening on the shaft wall.

An exit ring must be provided without exception if the strata at the level of exit happens to be loose.
The Contractor shall plan this work well in advance and fabricate the fittings and rubber seal as per approved method.

Machine exit in to the reception shaft will not be permitted unless the reception shaft is provided with proper exit ring.

9.9.16 Soil Improvement at the Tunnel Entry and Exit

In addition to the seal, it may be necessary to stabilize the soil behind the entrance wall. This is to prevent any free flow of unstable soils into the pit when opening is made for the shield to enter into the ground. Chemical grouting, cement grouting, jet grouting, piles, ground freezing or temporary shoring are some methods commonly used by the contractors to prevent the soil flow into the shaft.

9.9.17 Cement Grouting

The Contractor shall be fully responsible for preventing the occurrence of voids outside the pipe and if they occur he shall fill them with cement grout. Immediately following the jacking operation the Contractor shall pressure grout the jacked section to fill all voids existing outside of the pipe. Grouting shall be from the interior of the pipe through grouting holes as specified. The grout mix shall be at least of CM 1:3.

Systems of standard pipe, fittings, hose, and special grouting outlets embedded in the pipe walls shall be provided by the Contractor. Care shall be taken to ensure that all parts of the system are maintained free from dirt. Grout composed of cement, sand and other approved compound and water shall be forced under pressure into the grouting connections at the invert and shall proceed until grout begins to flow from upper connections. Connections shall then be made to these holes and the operation continued to completion.

Apparatus for mixing and placing grout shall be of a type approved by the Engineer and shall be capable of mixing effectively and stirring the grout and then forcing it into the grout connections in a continuous uninterrupted flow.
After grouting is completed, pressure shall be maintained by means of stop cocks, or other suitable devices until the grout has set sufficiently. After the grout is set, grout holes shall be completely filled with dense concrete and finished neatly without evidence of voids or projections.

9.9.18 Jacking System

The hydraulic jacking system shall be installed against a purpose-built thrust wall in the jacking shaft. The jacking force required for jacking pipes and the tunnelling/ boring machine shall be provided by high pressure jacks driven by hydraulic power packs with appropriate factor of safety. The ram diameter and stroke of the jacks may vary according to individual contractor's technique and to suite site conditions.

The jacks shall be mounted on specially made frames so that the jacks are square to the pipe alignment. The jacking frame shall be firmly supported to the floor so that it does not move during jacking operation. A push ring shall be used to transmit the jacking force evenly to the pipe.

There are jacking systems with multiple strokes or long stroke mounted on a specially made jacking frame available to push a full-length pipe in a single setting. The system does not require the use of spacers and hence a substantial increase in productivity can be achieved by using multiple stroke jacking system.

9.9.19 Jacking force

The Contractor shall calculate the anticipated jacking load for each micro tunnel/ pipe jacking/ auger boring drive well ahead of designing the jacking pipes. Accurate estimation of the jacking load is necessary to determine the pipe wall thickness, the need for intermediate jacking stations and lubrication requirements, types of jacking system and thrust block design. The overall jacking force depends on the type of surrounding soil, depth of cover, pipe materials, diameter and the overall length of the pipeline. The total jacking force essentially consists of two components, "Frictional force around the pipeline" and the balancing force at the tunnel face called "Face Pressure". The Contractor shall use appropriate geo-mechanics formulae and guidelines for computing the jacking force. The contractor shall calculate the anticipated jacking force for each drive and submit his calculation to the Engineer for approval.

The Contractor shall be solely responsible to ensure that the pipes are not subjected to excessive jacking force or torsional force so as to crush them. If such thing occurs the contractor shall have to remedy the situation at his risk and cost.

9.9.20 Pipe Lubrication System

The boring machines are commonly designed to overcut about 10mm (in some cases up to 20mm) around the external diameter of the pipeline. The pipeline can, in theory, be jacked freely through a fluid medium by injecting a clay based (bentonite) or polymer based lubricant into this annulus. In practice, however, fluid losses may occur into the surrounding ground. The contractor shall carefully monitor the jacking force and use appropriate lubrication system, to bring down the jacking force within the allowable jacking force for the pipe.

9.9.21 Protocol of each Drive

After completion of particular drive / work or as directed by the Engineer, Contractor shall submit within five days a proper & authentic `PROTOCOL' (both soft & hard copy) of Micro tunnelling machinery for that particular drive / work, to the Engineer. Protocol must reflect date time, length, various pressures of main jacks, steering jack's extensions, and cutter head torque & face pressure, slurry & feeder pumps-flow rate, pump pressures, deviations in vertical & horizontal alignment, roll, pitch etc. No extra payment shall be admissible for this requirement.

9.9.22 Special Traffic Precautions

The Contractor's attention is specially drawn to the requirements by the traffic police and road authorities and Specifications regarding Traffic Control, Access and the Reinstatement of road surfaces etc. It shall be the responsibility of the contractor to obtain permissions from traffic police and other authorities well in advance of the commencement of the works.

The Contractor's progress/ programme and road opening schedule must be arranged in details for discussion with the Engineer and the Traffic Police. The laying of pipelines must be broken into appropriate sections, and, where necessary, special traffic diversions arranged.

Whenever carriageways are affected, the Contractor must arrange to contain the works within the narrowest possible area. Excavated material must be removed as the work proceeds or contained within the areas designated by the Engineer/ Traffic Police.

The Contractor shall carry out the work in such a manner as to cause minimum interference with the public use of highways, footpaths, and other thoroughfares.

All workmen working on roads are required to wear approved retro-reflective vests at all times.
The Contractor shall include in his rates for compliance with all the conditions stipulated above.

9.9.23 Road Opening

Where Machineholes have to be constructed on existing metalled or concreted road, the Contractor is required to submit a detailed road opening schedule to the Engineer for approval.

The Contractor shall contain the works within the narrowest possible area when laying pipelines along metalled or concreted road.

Traffic flow must be maintained at all times along the roads affected by the work. Sufficient lighting, road signs, barricades and traffic diversion signs must be established along the sites of the works in accordance with the Traffic Police requirements and to the entire satisfaction of the Engineer.

The Contractor shall also comply with the conditions imposed by Traffic Police and Roads Opening Conditions and Requirements stipulated by any other Authority.

Upon the completion of the pipeline or Machineholes, the Contractor shall backfill and make good all disturbances to the road, side table, road kerb and drains to the satisfaction of the Authorities and the Engineer.

If required the pits shall be covered with decking plates with appropriate support so that all traffic shall be allowed to run over the decking. No extra payment shall be admissible for such arrangements and the contractor's rates shall be deemed to cover such requirement. If directed by the authorities or the Engineer, the Contractor shall construct temporary diversion roads at his own cost to allow the traffic to flow through during the construction.

9.9.24 Partial Covering up of Road in Busy Areas

Where it is unavoidable to locate machinehole shafts or working shafts for tunnels in busy roads, the top of the openings shall be covered by decking, leaving only the minimum required area open at the top to carry out work within the shaft. Vehicles shall be permitted to travel over such covers provided. The Contractor shall submit to the Engineer details of the partial covering. He shall allow for compliance of this requirement in his rates.

9.9.25 Reinstatement of Road and affected Surfaces

The Contractor shall carry out the reinstatement of road foundation and road surface in accordance with the Specifications and requirements of the Engineer and as stipulated in the contract specifications. This shall include machine-paving as and when directed by the Engineer. Where road markings are affected, the Contractor shall reinstate with thermoplastic instead of paintings to the satisfaction of the Engineer.

9.9.26 Safety

The Contractor shall provide adequate ventilation and efficient apparatus to keep all excavations, tunnels and pipelines free from all dangerous gases, whether generated in the soil strata or otherwise, and he shall take precaution to ascertain that they are in a safe condition before allowing his workmen to descend.

While working in existing pipeline or machinehole , the Contractor shall provide air blowers to ventilate the place as sewage gas usually contains a high proportion of hydrogen sulphide, methane and other toxic gases which in combination with oxygen is explosive. Approved gas monitors/detectors and oxygen meters shall be used to ensure that the place is free from all dangerous gases. The Contractor is required to appoint a Health and Safety Engineer (Accident Prevention Officer) to ascertain that the pipeline or machinehole is in a safe condition before allowing his workmen to descend and work. No smoking or naked flame shall be allowed in the pipeline or machinehole . Monitoring of the air quality shall also be carried out regularly by the Contractor's supervisor while work is in progress and work shall be immediately suspended should unsafe conditions develop.

The Contractor is warned that besides performing any work in existing pipeline or machinehole , connecting to or breaking into existing pipeline or machinehole also poses potentially hazardous conditions. The existing pipeline or machinehole to which connection is to be made should therefore be thoroughly ventilated and certified as safe by the Supervisor/ Safety officer before workmen are allowed to execute the connection.

The Contractor and his Supervisor/ Safety officer shall be solely responsible for safety of persons entering in to the pipelines or confined spaces like Machineholes/ pits.

9.9.27 Continuous working

If, in the opinion of the Engineer it is necessary, by reason of the safety of the works, or the restoration of interrupted services or for any other reason whatever, the Contractor shall, when so ordered carry out the works or any portion thereof continuously by day and by night without extra charge and allow for such a contingency in his Bid price.

It shall be clearly and definitely understood by the Contractor that no claims in respect of any of the above shall be allowed in the settlement of the Final Account.

9.9.28 Steel trenching works

Wherever the sub-soil conditions are expected to be of a soft and unstable character, the normal methods of timbering may prove insufficient to prevent subsidence of the adjoining road surfaces,

drains and canal and other services or adjoining buildings and structures, in such circumstances the Contractor will be required to use steel trench sheeting or steel sheet piling adequately supported by timber or steel struts, walling, etc.

Steel sheet piles shall conform to the provision of I. S 2314 or B.S. 4360 and shall be driven where required as directed by the Engineer.

The Contractor will be required to design the layout of the piling and the overall dimensions of the excavation to suit the sheets and corners available and to give sufficient working space for the proper construction of the work.

The Contractor will be expected to supply, pitch, drive and subsequently remove trench sheeting or piling in accordance with other items of the Specification and the terms "timber" or "timbering" shall also apply to steel trench sheeting or steel sheet piling throughout.

Alternatively, the Contractor may use trench boxes capable of supporting the ground in the given conditions. However, no extra payment shall be made on this account.

Contractors shall be solely responsible for design, installation and removal of any shoring or timbering or sheeting system and their adequacy and safety. The rates quoted by the Contractors shall be inclusive of such measures of providing steel sheeting or sheet piling.

9.9.29 Sewage in the connecting sewers

The pipelines installed under this Contract are meant to connect to the existing functioning upstream and downstream functioning sewers. These pipelines are carrying sewage (stagnant or flowing) and may also be in surcharged conditions at times.

9.9.30 Connection to existing sewers

The Contractor shall note that the connecting pipelines/ branches might have been laid sometimes back and would be full of stagnant sewage/ water and might also have some unknown connections. The methods adopted by the contractor for making connections of such lines shall take due cognizance of such circumstances as no extra payment shall be made on such account.

The Contractor shall note that in connecting pipelines to existing sewers, every care shall be taken to ensure that the connections are watertight and the existing pipelines are not damaged. Special precautionary measures shall be taken to ensure the stability of the pipelines connected to them.

The Contractor shall ensure that there is no interruption to existing flows during the connection works. No debris shall be allowed to fall or be discharged into the existing pipelines or Machineholes. Any debris which falls into the existing pipeline/ Machineholes and any obstructions thereby caused shall be removed at the Contractor's expense immediately.

All connection to existing pipelines shall be subject to water tightness test and must meet the requirement for the same.

It shall be noted that during connecting the newly laid sewer line to the existing sewer, or for connecting cross sewers to the newly laid sewer, or to repair existing sewer, the contractors shall make necessary arrangement at his own cost, to procure Pneumatic plug / Inflatable plug / mechanical plug / Pillow plug for plugging existing sewer line. Plugging existing sewer by using mud / sand filled gunny bags will not be permitted. Plugging shall be done in co-ordination with & as directed by concerned

staff of Main Sewer Dept of BWSSB.

Safety measures for use of Sewer Plugs - Contractors need to ensure that the sewer plug is inspected prior to each use. The plug shall be partially inflated and inspected under low pressure for any obvious wear, tear, cuts, abrasions or damage. Also, examine the accessories with which the PLUG is to be inflated.

Inflation pressures as in the Manufacturer's instruction manual and on the plug, must be adhered to when inflating the plug, but never exceeds the max. Working pressure. Check the internal pressure in the PLUG regularly.

Utilizing an air line extension plugs can be inflated from a distance, away from the danger zone or outside

The PLUGS shall only be used by persons who have been properly instructed and who are trained for the use.

When using the PLUGS, the safety of the user and any bystanders must always be borne in mind, as wrong use can cause life threatening situations.

Contractors shall consider measures to brace for and absorb the impact of plug failures and to prevent the PLUG from sliding out. This may include anchored ropes/cables in upstream Machineholes, bracing in the chase of the plugged machinehole , or a combination of methods, all with associated risk assessments and controls in place.

Ensure only the use of approved and calibrated pressure gauges. And also ensure pressures are monitored and controlled during plug inflation / deflation with calibrated gauges.

The Contractor shall allow for all the above in his rates.

9.9.31 Laying pipelines in residential areas

The Contractor shall note that if the pipeline has to be laid in close proximity to existing premises. He shall take all necessary precautions, including the provision of steel sheet piling cut-off walls where necessary, to prevent any damage to the existing premises and shall be responsible for the damage and complete repairs of the same.

The Contractor shall be responsible for obtaining permissions from the owners of private premises if needed by him for his work. He shall be responsible for restricting his workmen to the site of the work while working in private premises. If the Contractor considers it essential to have additional working space he may obtain the same from private property owners entirely at his risk and cost. The Engineer is not bound to arrange for such facilities from private property owners.

Temporary fencing shall be erected as directed by the engineer to separate the worksite from the rest of the private premises at the Contractor's own expense for all execution.
Turf, walls, slopes, fencing, shed or any other structures whether directly or otherwise disturbed or damaged by the construction work shall be reinstated to the original conditions by the Contractor at his own expense.

The Contractor shall allow in his rates for complying with these requirements as no claim to the contrary will be entertained by the Employer/ Engineer.

9.9.32 Hydraulic testing of Sewer line & Handing over of completed works

Upon completion of works the sewer lines including rising mains shall be hydraulically tested as per the required head/ pressure as per CPHEEO manual provision of specifications. After successful testing, the contractors must clean the site as per the satisfaction of the Engineer and the same shall be handed over by the contractor to the user department under proper acknowledgement and certificate to this effect.

Hydraulic testing and cleaning up the site on completion is to be done by the contractors at his own cost and no extra payment shall be admissible for this requirement.

All works to be water tight

(a) The drains, Machineholes and all joints of pipes must be made thoroughly sound and water tight, and any joint which may be proved to be leaky at any time during the progress of the works or during the contractors' subsequent period of maintenance shall be immediately made sound by the contractors at their own expense. The contractors, when required by the Engineer shall at their own cost prove all works to be water tight by filling it with water to such height as the Engineer may determine. Any additional precautionary measure or appliances that may be found necessary to ensure the water tightness of the Machineholes, flush tanks, disc plug in junctions and the joints of pipes shall be adopted by the Contractor without extra charge, the responsibility of making them completely water tight resting upon the contractors.

Complete sewer inspection of inside of pipe shall be carried out with help of CCTV sewer inspection camera and a record of the same shall be maintained in the form of CCTV footage with proper indexing/ subtitles/ overlays etc and submitted to the Engineer (3 copies) on DVDs.

(b) Immediately after the CCTV pipe inspection has been completed and any defect discovered therein has been made good the Contractor shall prove the joints of the stretch of under-ground carrier pipes, to be water tight by filing in pipes with water before filling in the trench to the level of 1.50 M above the top of the highest pipe in the stretch and heading the water up for the period of one hour or such further time as the Engineer may direct. The apparatus used for the purposes of testing shall be approved by the Engineer. The contractor if required by the Engineer shall make the excavation dry and keep it so during the period of testing. No test applied to part of a stretch of pipes shall be considered conclusive nor shall it be deemed to obviate the necessity of an application of the test to the whole of stretch when completed. The loss of water (ex-filtration) or rise in water volume (infiltration) over a period of 30 minutes should be measured by adding water from a measuring vessel at regular 10 minutes and noting the quantity required to maintain the original water level. For the purposes of this test the average quantity added should not exceed 1 litre/hour/100 linear metres/10 mm. of nominal internal diameter.

Works not within above specified requirements shall stand rejected and shall be rectified by the Contractor at his risk and cost.

The Machineholes when they have been raised above the highest subsoil water level expected in the monsoon shall similarly be tested for water tightness as for the pipelines. The procedure for this shall be as follows:-

The mouths of all pipes entering the machinehole shall be suitably plugged with brick, masonry or wooden or any other type of plug. The machinehole under test shall then be filled with water up to the

general sub-soil water level and observed for a period of one hour. If the level does not drop by more than 50 mm. in one hour it shall be assumed that the machinehole is water tight.

Note for pipe laid by open trenching only: During the period of the test the outside trench shall be kept free from any accumulation of subsoil water in case of a drop of more than 50 mm in the water level the contractor shall note the places from where the leakage is taking place & take steps to stop the leakage.

(c) Cleaning of the pipes

The open end of an incomplete stretch of pipeline shall be securely closed as may be directed by the Engineer to prevent entry of mud or silt etc.

(d) If as a result of the removal of any obstruction the Engineer considers that damages may have been caused to the pipelines, he shall be entitled to order the length to be retested at the expense of the Contractor. Should such retest prove unsatisfactory, the contractor shall at his own expense amend the work and carry out such further tests as are required by the Engineer.

(e) It shall also be ascertained by the Contractors that each stretch from machinehole to machinehole is absolute clear and without any obstruction by means of CCTV inspection of the interior of the pipeline.

All works to be clear, clean and perfect

The contractors shall after completion or whenever required by the Engineer, prove all pipes and fitting to be clear clean and perfect, and for this purpose shall, at their own expense and in the presence of the Engineer or his appointee, provide suitable instruments and appliances and pass them through the pipes and shall if required, throw in water and show that it passes freely through every portion of the work. Brick, mortar and rubbish shall not be allowed to fall into the Machineholes of sewer lines while fixing or if allowed, shall be removed by the Contractors at their own expense.

Remedial Measures to be adopted by the Contractor

The Contractor shall take each and every precaution to ensure that the tunnelling or drilling equipment will successfully excavate along the chosen pipeline alignment before he commences the operation. In the event of inability to complete the drive, due to break down or any other reasons, the Contractor shall be fully responsible to recover the equipment safely from the ground and restore the incomplete work to the original condition at his risk and cost by a method agreed with the Engineer and the concerned authorities within the time stipulated by the Engineer or the concerned authority.
The cost for such retrieval measures or any consequential expenditure or delays arising from thereof shall be entirely borne by the Contractor. Any failure of remedial measures shall be entirely at the risk and cost of the Contractor. Any abandoned hole or tunnel must be backfilled to the top of the hard strata with concrete or gravel with grouting to provide a solid infill, or other method agreed with the Engineer completely at the Contractor's cost so as to prevent subsequent settlement.

Inspection and Replacement of Defective Work

(a) At any time during or after the execution of the Works the Contractor shall, at the request of the Engineer and within such time as the Engineer shall name, open for inspection any work covered up and should the Contractor refuse or neglect to comply with such request, he shall employ other workmen to open up same.

(b) If the said work has been covered up in contravention of the Engineer's instructions, or if on being opened up it be found not in accordance with the Drawings, Specification and Bills of Quantities or the instructions of the Engineer, the expenses of such opening and covering it up again, whether done by the Contractor or such other workmen, will be borne by and is recoverable from the Contractor.

(c) Wherever in the opinion of the Engineer the work done is inadequate or of poor workmanship or inferior materials or in any way sub-standard such works will be demolished, cut out and removed from the Works immediately and replaced with new materials of the required standard and quality at the Contractor's risk and cost.

Taking photographs

Contractor at his own cost shall take, print, supply album of photographs (Two sets) in an album during the construction work in progress. The photographs shall be submitted fortnightly or as directed by the Engineer. No extra payment shall be admissible for this requirement.

CCTV Survey

It is mandatory for the contractor to carry out CC TV Survey including submission of two soft copies & two hard copies to the Engineer after completion of particular drive / work along with Machineholes or as directed by the Engineer. No extra payment shall be admissible for this requirement.

Handing over of completed works

Any pipe or length of pipes found to be defective shall be immediately removed and replaced at the Contractor's expense and leaking joints shall be remade, the inspections and tests shall then be repeated as often as necessary until the whole line under inspection or test is accepted by the Engineer. Upon completion works and successful testing of completed works the same shall be handed over by the contractor to the user department under proper acknowledgement and certificate to this effect.

End of Part-11

PART 12

PARTICULAR ELECTRICAL PLANT REQUIREMENTS

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PART 12

PARTICULAR ELECTRICAL PLANT REQUIREMENTS

12.1 Introduction

The specific design and performance requirements for all electrical equipment are given in this part of the Specifications. The Requirement specified shall be fully met with by the Contractor. In case of any deviations, the Contractor shall bring out the same in "Schedule of Deviations from Particular Requirement" failing which shall be considered that the Contractor fully complies with these requirements. General Requirement of electrical equipment is covered under Part-6 of this specification.

12.2 Scope of works

The scope of works for WwTP / TSPS / Lift Pumping Stations includes design; manufacture; testing at works; supply and delivery at site; unloading and storing the equipment at site of installation; installation, testing and commissioning of the following equipment at site.

11kV Outdoor VCB Panel/11kV ICOG panels, 11kV Indoor Metal enclosed Switchboards, 11/0.433kV transformers, 415V Diesel Generator Sets with Acoustic Enclosure & AMF Panel, 415V Metal enclosed switchboards / distribution boards / Power Control Centres / Motor Control Centres / Local control Panels / Junction Boxes, 415V capacitor banks with detuned filters and APFCR panel, 110V DC Battery, Battery charger, DC Distribution board, LV Variable Frequency drives, Active Harmonic Filter Panel (AHF), 415V Non segregated bus ducts, LED Lighting system, Power & control cables, Cable carrier & support system, Earthing & Lightning protection system, solar PV System.

All equipment / items shall be of makes as specified in the list of preferred makes. Various equipment/ items shall conform to latest applicable standards specified and latest amendments. In case of Conflict between standards and this specification, this specification shall govern.

12.3 Power Supply Arrangement

At the proposed WwTP / TSPS / Lift Pumping Stations plant locations there is no existing incomer power arrangement and hence incoming power supply shall be taken new from the nearest BESCOM substation as per below voltage level

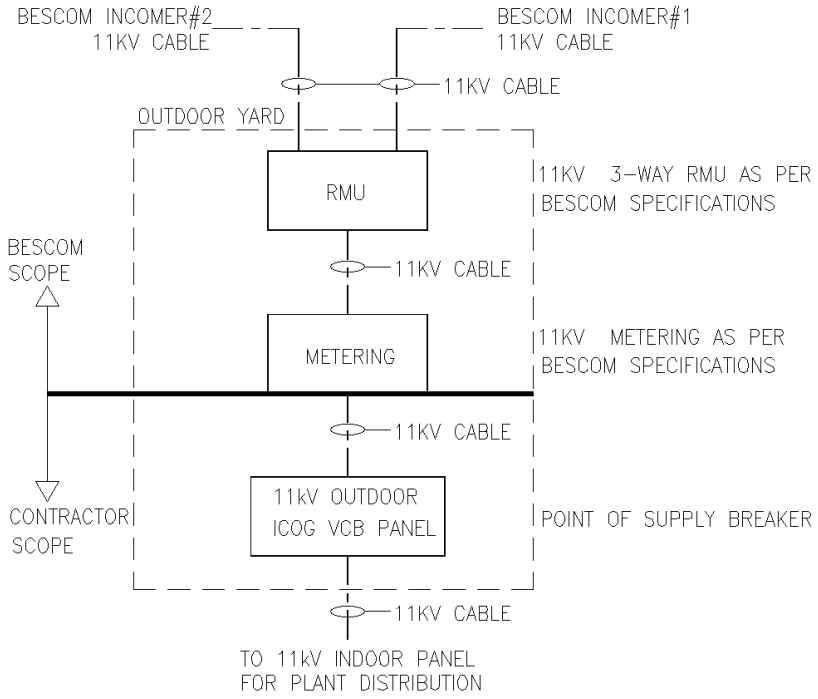
- WwTP & TSPS - 11kV (HT)
- Lift Pumping Stations - 415V (LT)

BESCOM shall making necessary modifications in their substation by adding extra 11kV switchgear / Breaker, laying 11kV overhead line / underground cable up to the RMU/Spun Pole in new WwTP / TSPS location. Necessary RMU/Spun Pole, CTs, PTs, interconnecting cable from RMU/Spun Pole to metering unit, metering unit shall be provided by BESCOM.

The Incoming 11kV (overhead line / underground cable) supply from BESCOM shall be terminated at RMU/Spun Pole. Outgoing terminals of the RMU/Spun Pole shall be connected further to outdoor/indoor 11kV BESCOM metering unit.

The outgoing cable from the metering unit shall be connected to Outdoor VCB (point of supply commencement breaker) and further connected to incomer of 11kV Metal Enclosed Switchboard at WwTP/TSPS. The above-mentioned works upto the BESCOM metering unit will be executed by

BWSSB/BESCOM. The above works may be carried out by BWSSB as Deposit Contribution Works or Self Execution Basis which may be decided by BWSSB after the award of contract.



Works for WwTP/TSPS starting from outgoing side (cable termination point) of 11kV metering, providing an outdoor VCB panel after BESCOM metering as a point of supply commencement breaker & all works as mentioned above will be included under contractor scope.

Power from the 11kV indoor panel for plant distribution shall be distributed as shown below

WwTP:

The outgoings of the 11kV indoor panel for plant distribution shall feed

- 2 Nos. of 11/0.433kV Distribution Transformers for WwTP plant loads.
- 2 Nos. of 11/0.433kV Distribution Transformers for Process Air Blowers loads.

The maximum distribution transformer rating shall be restricted to 2500kVA.

The 415V side of the transformers shall feed to 415V PCC panel through Air Insulated Bus Duct/ LV Cable. Further power to the plant loads shall be provided by MCC panels and starter panels.

Lift Pumping Stations:

The Incoming 415V supply for the lifting stations shall be derived (overhead line / underground cable) from nearest BESCOM line and shall be terminated at consumer Switch-fuse unit / MCCB and then to BESCOM LT Meter. The 415V supply from the LT meter shall feed to 415V LT panel and then to starter panels of the lifting stations for further distribution.

Liaisoning with BESCOM for getting construction power supply, making new power supply agreement for the plant, and getting final clearance from CEIG for complete Electrical system will be included under contractor scope.

Contractor to provide the electrical system based on their design and with reference to the tender specifications.

Contractor shall consider separate rooms in main substation for accommodating LV panels, MV panels, AC UPS, DC Battery system, PLC/Control panels as a minimum. Transformer yard shall be outdoor with fencing & gates and shall be attached to the main substation such that MV cable lengths and bus duct lengths are straight & short as far as possible.

Contractor shall design the electrical system distributing the loads under various load centres with MCC panels. Each load centre shall have necessary provision for monitoring the specific energy consumption and shall be connected to plant SCADA for remote monitoring/display.

- TSPS units
- Preliminary Treatment Units
- Primary Treatment Units (wherever applicable)
- Biological Treatment Units (Including blowers)
- Tertiary Treatment Units
- Reuse Facilities (wherever applicable)
- Disinfection System Units
- Sludge Handling Units
- Other miscellaneous Units

Separate MCC panel rooms shall be considered for placing MCC panels, lighting panels & PLC panels (if any) for TSPS pumping station, Primary Treatment, centrifuge buildings, Air Blower building, Chemical building & Chlorination buildings as a minimum.

12.4 Roof Top & Tank Top Solar Power Generation

12.4.1 On Grid connected Solar PV System

Contractor shall install a grid-connected PV system consisting of a solar PV system working in conjunction with the utility grid. Refer Volume 2/Section 7, Part 6 for the General Electrical Requirements related to the Solar PV Panel and components.

Contractor shall design the electrical distribution system in such a way that

- During the day, solar power shall be utilized to the maximum extent for feeding plant loads, and any additional power requirement shall be met from the grid.
- During the night, and in case of the non-availability of sufficient sunlight, power shall be fully drawn from the utility grid.

Major components of the System shall be:

a) Solar PV crystalline modules
b) Module Mounting Structures and Civil Structures
c) Junction Box, DCDB
d) String Inverter, ACDB
e) Step-up Transformer (if applicable)
f) Cables & Metering Accessories
g) Earthing and lightning protections (Integral to PV system)
h) Conduits, pipes and accessories

Contractor shall refer the KERC Regulations 15th Dec 2016 or latest amendments, for Solar rooftop plant capacity voltage level which is as per below

- upto 50kW - the voltage level LT, 3 Phase 415V
- above 50kW and upto 1000kW - the voltage level HT, 3 Phase, 11kV

PV panels produce DC power, which is collected through junction boxes at each PV panel and fed to the DC Distribution Board (DCDB). DC power from the DCDB is converted to AC power with an inverter and connected to the AC Distribution Board ACDB.

Plant Capacity upto 50kW

Power from ACDB is connected to a 415V LT panel. The panel will have one incomer from the utility grid, another from the Solar PV system, and outgoings to the WwTP plant LT loads. Typical Scheme is provided under Figure 12.1 for reference.

Plant Capacity above 50kW

Power from ACDB is connected to a 0.433/11kV step-up transformer, which is further connected to the plant 11kV Panel. Typical scheme is provided under Figure 12.2 for reference.

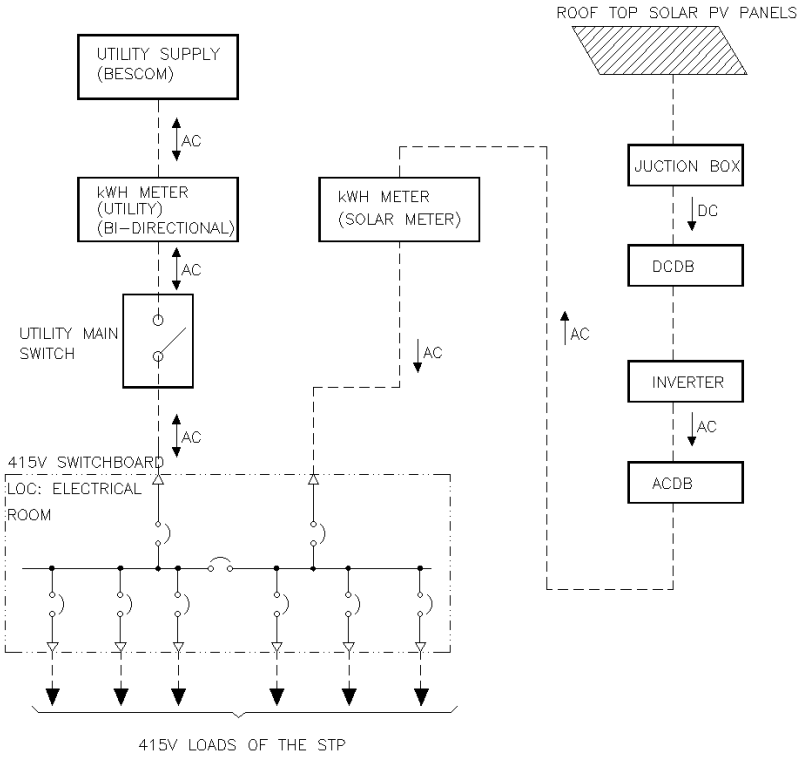


Fig 12.1: Typical Scheme for On Grid Roof Top & Tank Top Solar PV System for Plant Capacity upto 50kW (for reference only)

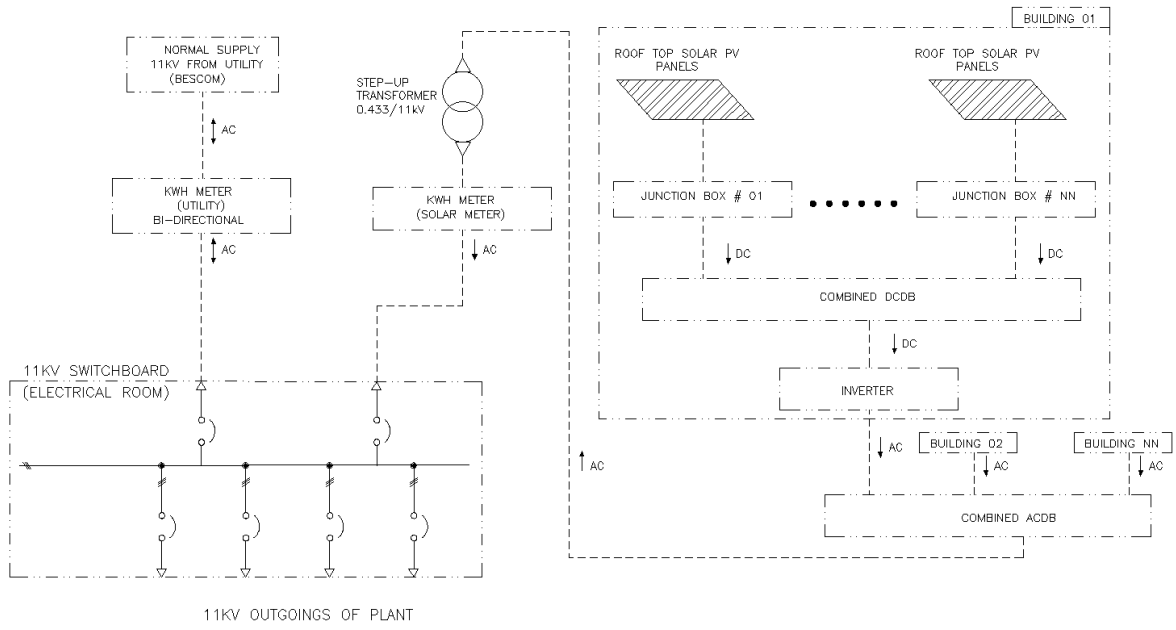


Fig 12.2: Typical Scheme for On Grid Roof Top & Tank Top Solar PV System for Plant Capacity above 50kW & upto 1000kW (for reference only)

a) Details of proposed Roof Top & Tank Top Solar Power Generation in WwTP

The below list of buildings in WwTP shall be considered **a minimum for Rooftop Solar** power generation with solar PV panels installed capacity of not less than 300kW considering minimum solar PV output of 540Wp per panel & module efficiency 20% (minimum) with minimum panel installation surface area requirements as per below table.

A minimum of 70% of the roof area of each building shall be considered for solar PV module installation, and 30% space of the total rooftop area shall be left for solar PV module maintenance & walkway. The minimum Surface Area to be made available for Solar PV Panel Installation on Roof of all the Buildings and on Tank Tops (excluding 30% maintenance area) shall be minimum 1900 Sq. mtrs. The power generation from the Solar PV panels on roof top and tank top shall not be less than 4,50,000 kWh/year (37,500 kWh/Month) failing which a penalty will be levied as per Technical Schedule X of Volume 2, Section 7B.

Sl. No	Building Name	Type of Installation	Area after Leaving 30% Space for Maintenance & Walkway (sq.mtrs)
	20 MLD STP Channasandra		
1	Admin Bldg.	Roof Top	84
2	Chlorination Bldg.	Roof Top	67
3	Chemical Bldg.	Roof Top	84
4	Blower Bldg.	Roof Top	176
5	Centrifuge Bldg.	Roof Top	67
6	Centrifuge Feed PH	Roof Top	56
7	Disc Filter Bldg.	Roof Top	20
8	SBR Tank Area (2 Tank Area)	Tank Top	1,156
9	Plant DG Bldg.	Roof Top	84
10	Electrical substation Bldg.	Roof Top	105
	Total Surface Area for Solar PV Panels in Sq. mtrs.		**1,900**

Contractor shall provide the detailed plant layout plan for the buildings/structures showing the Solar panels installation as per the contract specifications. Contractor shall submit detailed

calculations/drawings for the solar power generation, equipment selection (inverter, ACDB, DCDB, cable sizing, transformer etc.), single line diagram, solar panel arrangement drawing, solar PV and components technical data sheet, Quality Assurance Plan.

The module mounting structures shall have the following characteristics or better.

	All the buildings as per above except Anaerobic/Anoxic/Aerobic Area (or) SBR area	**For Anaerobic/Anoxic/Aerobic Area (or) SBR area**
Typical Installation Photo		
Roof Area	Flat RCC Roof	Open area to Sky
Material of Frame Structure	Aluminium of min. 2.5 thickness Aluminium shall be as per AA6063 T6.	Hot Dip Galvanizing confirms to IS4759:1996 maintained 650 GSM (80-90microns) as per MNRE standard
Type of Mounting Structure	Shall be suitable for Flat RCC Roof	Special Mounting Structure over the Anaerobic/Anoxic/Aerobic Area
Corrosion Resistance	Mounting Structure shall be anodized to increase the corrosion resistance and wear resistance in the material	Mounting structures shall be provided with protective coating as per Corrosion Classification of C5 as per IS 14191-2024 / ISO 9223-2012.
Wind Speed	Shall be designed to withstand the speed for the wind zone of the Bengaluru location.	Shall be designed to withstand the speed for the wind zone of the Bengaluru location. The PV array structure design shall be appropriate with a factor of safety of minimum 1.5.
Installation Height of Solar PV Panels	1.2 mtrs. above Roof area of Building	5 mtrs above Tank Operating Platform

12.5 General Design Criteria for WwTP & TSPS / Lift pumping stations

All electrical equipment shall be rated for 45 ^{0}C design ambient temperature. The installation shall conform to Indian Standards / IEC.

The following factors shall be considered for proper selection of electrical apparatus or equipment for areas where flammable gas or vapours may rise.

12.5.1 Area classification

The classification of area shall be as per IS 16724: 2018 & IS 5572, based on the degree of probability with which explosive concentrations of combustible gas or vapour may arise in installations in terms of both the frequency of occurrence and probable duration of existence on each occasion.

(i) Zone 0 – In which an explosive gas/air mixture is continuously present or present for long periods.

(ii) Zone 1 – In which an explosive gas/air mixture is likely to occur in normal operation.

(iii) Zone 2 – In which an explosive gas/air mixture is not likely to occur in normal operation and if it occurs, it shall exist only for short periods.

Gas Group Classification

The characteristics of the gas or vapour involved in relation to igniting current or minimum ignition energy in case of installations of intrinsically safe apparatus or maximum experimental safe gap data in case of installations for flame proof enclosures as per IEC 60079-1.

Temperature Classification

The Ignition temperature of the gas or vapour involved, or the lowest value of ignition temperature if more than one combustible material shall be present.

The maximum temperature of any unprotected surface of electrical equipment shall not exceed the ignition temperature of gas or vapour. For electrical apparatus, no margin of safety need be applied between maximum surface temperature and ignition temperature. The ignition temperature of combustible gases and vapours are measured in accordance with the test method prescribed in IS/IEC 60079-20-1.

Environmental conditions

Environmental conditions in which the apparatus shall be installed. Apparatus and its component parts shall be constructed to guard against electrical and mechanical failures in the intended conditions of use.

The selection of type of protection of electrical equipment for the different zones of Hazardous areas shall be made in accordance with IS 16724 / IEC 60069-14.

All electrical equipment installed in hazardous areas shall confirm to selection of equipment and installation guidelines of IS 16724 / IEC 60069-14.

12.5.2 MV System

(i) Nominal voltage	:	11kV
(ii) Number of phases	:	3
(iii) Frequency	:	50 Hz
(iv) Connection	:	3 Wire
(v) Maximum Fault Level/current	:	500A (26.25kA)

12.5.3 LV System

General Supply

(i) Voltage:	:	415 V nominal
(ii) Frequency:	:	50 Hz

(iii) Connection	:	4 wire
(iv) No load transformer voltage	:	433 V
(v) System earthing	:	Solidly earthed
(vi) Maximum fault level/current	:	36 MVA (50kA)

All Plant shall, unless otherwise specified, be capable of continuous operation at a voltage level in the range of 90% to 110% of the relevant nominal voltage and a frequency variation of plus 5% minus 5% with a maximum combined tolerance of 10%.

12.5.4 AC Control, Lighting and Space Heating

- Voltage: 240 V
- Phases: 1
- Frequency 50 Hz
- Connection 2 wire (Phase & Neutral)

12.5.5 DC Control, Protection and Alarm

- Voltage: 110 V
- Phases: 1
- Connection 2 wire (unearthed)

12.5.6 System Protection

Numerical relay-based protection system for various parts of the power supply system shall be proposed. The following protection systems shall be used:

(a) 11 kV Incomer Feeder

- Instantaneous phase over current protection
- Instantaneous earth fault protection
- Inverse definite minimum time phase over current protection
- Inverse definite minimum time earth fault protection
- Potential transformer fuse failure protection
- Under voltage protection
- Negative phase sequence protection
- Breaker failure protection
- Inrush protection

(b) 11 kV Transformer Feeder

- Inverse definite minimum time phase over current protection
- Inverse definite minimum time earth fault protection
- Instantaneous phase over current protection
- Instantaneous earth fault protection
- Standby earth fault Protection
- Thermal overload protection

- Inrush protection
- Breaker failure protection
- Winding temperature high, alarm &trip
- Oil temperature high, alarm &trip
- Buchholz relay alarm and trip
- Magnetic oil level gauge alarm
- Restricted Earth Fault relay to be provided for Transformer rating 2MVA and above
- Pressure relief valve alarm & trip
- Oil surge relay trip
- Alarm annunciation with connectivity (communication port RS485) to PLC

(c) 415V Incomer Feeder

- Overload, Earth fault and short circuit protection
- Under voltage Protection

(d) LV Motors

(i) Motors upto 11kW

- overload protection by three phase thermal (bimetal) relay
- Single phasing preventer
- Motor Protection Circuit Breaker (MPCB)

(ii) Motors 15kW up to 75kW

- Electronic motor protection relay providing the following protection
- Overload
- Earth fault
- phase currents out of balance
- Single phasing preventer
- MCCB

(iii) Motors above 75kW

- Comprehensive motor protection relay providing the following protection
- Thermal Overload
- locked rotor
- Phase Over current (50/51)
- Earth fault (50N/51N)
- Over voltage & under voltage
- phase loss/reversal
- Negative sequence
- Protection for repeated and prolonged starts
- restart inhibition
- Single phasing preventer

- Temperature Monitoring (Alarm & Trip)
- ACB/MCCB

Note: - RTD's of Winding and Bearing Temperatures of Pumps / Motors shall be monitored through Temperature Scanner Indicators.

(iv) Pump Drives

All pumps shall be provided with the following additional protection, as per requirement:

- Dry run protection
- Temperature protection, (Submersible pumps)
- Moisture entry protection. (Submersible pumps)
- Over pressure (positive displacement pumps)

(v) Blowers

Blowers shall be provided with the following additional protection:

- Over pressure

(vi) Rotating Arm Drives

Rotating arm drives shall be provided with the following additional protection:

- motion detectors
- Over torque detectors

(vii) Valve Actuator Drives

Valve actuator drives shall be provided with the following additional protection:

- Over torque detectors

12.5.7 Switchgear Instruments

(a) 11kV Feeders (Incomer, Transformer & outgoing feeders)

- Analog Ammeter for all 3 phases
- Analog Voltmeter with selector switch
- kW meter
- kWh meter
- kVARh meter
- Frequency meter
- Power factor meter.
- Digital Multifunction meter with RS 485 connectivity

(b) 415V Incomer Feeders

- Ammeter with selector switch
- Voltmeter with selector switch
- kW meter
- Digital Multifunction meter with RS 485 connectivity

(c) 415V Motor Starter Feeders

- Ammeter with selector switch
- Voltmeter with selector switch
- kW meters for Motor feeders more than 75kW
- Multifunction meters with facility to extract historical data for Process Air Blower Feeders
- DOL Starters for motor feeders less than or equal to 5.5kW
- Star-Delta Starters for motor feeders above 5.5kW and up to 30kW
- Line/Neutral Soft Starters for motor feeders above 30kW

12.5.8 MV Metal Enclosed Switchboard

MV switchboard shall be 11kV and shall be floor standing, sheet metal enclosed with IP4X degree of protection, draw out type vacuum circuit breakers for incoming & outgoing feeders, control & protection. The switchboard shall be rated for a fault current not less than 26.25 kA (rms). All protective relays shall be numerical type. Indoor MV Panel shall be suitable for top cable entry and outdoor MV Panel shall be suitable for bottom entry.

12.5.9 Distribution Transformer - 11/0.433kV Transformers

The transformers shall be outdoor type, ONAN, 11/0.433 kV, 3 phase, 50 Hz, two winding, Dyn11 with solidly earthed neutral with OLTC. The energy efficiency level (EEL) of the transformer shall comply with the latest amendment of IS 1180 with minimum EEL of Level II.

The transformers shall be sized considering 15% contingency of total working load while arriving at the final capacity of transformers. Two numbers of transformers shall be provided in each load location such that under normal condition, each transformer shall be loaded up to 50% and in case of failure of any one transformer, the healthy transformer shall have capacity to take entire load so as to have 100% standby.

The transformers shall be designed such that at any point of time maximum loading (including Contingency Capacity) on any single transformer shall not exceed 85% of full load capacity. The maximum capacity of the distribution transformers shall be limited to 2500kVA.

12.5.10 Standby Diesel Generator Sets

Diesel Generator Sets shall be provided with Acoustic Enclosure and AMF panel with Air Circuit Breaker (ACB) at WwTP/TSPS and sized for power back up of all the WwTP/TSPS loads which requires continuous operation of the corresponding WwTP/TSPS plant during main power failure. 10% contingency over these loads shall be considered while sizing the DG Set.

All DG Sets shall be in compliance to CPCB IV emission norms.

<u>Automatic Main Failure Panel</u>

AMF (Automatic Main Failure Panel) panel shall be provided for the Diesel Generator Set. In case of mains failure detected by an under-voltage relay mounted in the AMF panel, the main breakers (receiving the main power from BESCOM) shall be switched off under auto mode. Consequently, the standby generator starts in the auto mode. After the generator set reaching the rated speed and rated voltage, the generator circuit breakers shall be switched on to feed Diesel Generator power to the AMF panel. On restored main supply, the reverse sequence of the above shall be followed for the mains supply to feed power to the loads as in normal condition.

12.5.11 415V PCC / MCC

415V PCC/MCC & 415V DG PCC shall be Single front, floor standing, top cable entry, sheet steel enclosed with IP 54 Degree of Protection, Form–IV enclosure as per IS/IEC 61439 complete with Air circuit breakers/MCCB's /MPCBs, Control & Protection. The PCC / MCC shall be rated for a fault current not less than 50kA (rms) for 1 sec.

Double front construction may be acceptable only in case of space restrictions in the Electrical Room and for motor starter feeders and small feeders (below 630A).

All feeders of ratings 800A and above shall be ACB type. Feeders below 800A and upto 63A shall be MCCB. Ratings below 63A shall be MCB. Motor feeders upto 15kW shall be with MPCB.

In general, all switchgear/MCCs shall be provided with 20% fully equipped spares feeders/breakers. All Motor Feeders in the MCC Panels shall have Contactors, ON-OFF-Trip indication and OLR reset button.

12.5.12 415V Bus Duct

Bus duct shall be considered for handling short distance high current requirement i.e., from transformer secondary to 415V PCC / 415V Main LT panel & DG PCC panel to 415V PCC / 415V Main LT panel. Bus duct shall be considered for power requirements greater than 1000kVA.

Bus ducts shall be sized for continuous current carrying and short circuit withstand capacity

12.5.13 Local Control Panel (LCP)

For each motor:

- Local / Off / Remote selector switch to be provided. 3 Push buttons "START / STOP / EMERGENCY STOP" shall be provided.
- Start push button operates only when the switch on LCP is in "Local" position.
- Stop push button shall operate only after pre-determined requirement of closing the delivery valve either in Local mode or Remote mode for 90kW and above pump motors.
- Emergency Stop push button operates irrespective of the position of the selector switch.

When the selector switch on LCP is in "LOCAL" position, the motor shall be operated by push buttons on LCP and shall take into account only the specific fail-safe controls of the equipment (electrical protections, low level for a pump). When the selector switch on LCP is in "REMOTE" position the drive shall be operated from PLC. LCP shall be suitable for top cable entry for indoor installation and bottom entry for outdoor installation.

Motorized valves shall be with fully integrated control Actuator. The actuator comes with integrated:

- One Selector switch "Remote / Local"
- Control switch for: OPEN / CLOSE / STOP.
- Local Control cubicle with remote operation from PLC with position feedback.

12.5.14 Operation Logic of Switchgears

Operation Logic of 415V Metal Enclosed Switchboard at Substation:

- At normal condition, both the Incomers shall be in Closed Position and the DG Incomer & Bus coupler shall be in Open Position.
- If any Incomer fails the faulty Incomer shall be in Open Position, the Bus coupler and the healthy Incomer shall be in Closed Position.

- In Case of Power Failure, DG Incomer & Bus coupler shall be in Closed Position and the Mains Incomer shall be in Open Position. The critical loads of the plant shall run on DG Set.

12.5.15 Capacitor Banks and Power Factor Correction

The LT capacitor banks provided shall be of bus connected type with Automatic Power factor correction, the system shall be designed such that a power factor of not less than 0.98 shall be maintained.

Automatically controlled multistage power factor correction shall be provided. 2 Nos. PFC panels providing no less than 8 number PFC stages per panel shall be provided each connected to one bus section of the LT Switchboard. The PF on each bus section of the board shall be monitored and corresponding PFC capacitors switched in and out automatically in discrete stages to maintain a set point PF value.

Each panel shall be configured such that no PFC capacitor stages operate when the standby generator powers the side of the distribution board to which it is connected. Reactors shall be provided for the protection of capacitors.

MCCBs, Switches, Contactors shall be suitable for making and braking current of the capacitors. The Panels shall be floor standing, sheet steel enclosed with relevant degree of Protection. APFC/Capacitor control panel shall be suitable for top cable entry.

12.5.16 Variable Frequency Drives

The following minimum loads shall be provided with Variable frequency Drives with a communication port:

- TSPS Pumps
- Process Air Blowers
- Mixed Liquor Recycle Pumps
- Return Activated Sludge Pumps
- Centrifuge Feed Pumps
- Dewatering Centrifuges
- Alum Dosing Pumps
- Polymer Dosing Pumps

The below loads shall have separate individual VFDs for each type of load. Group loads operation from a single VFD panel is not allowed. VFD Panels shall be suitable for top cable entry.

12.5.17 Active Harmonic Filter (AHF)

This section specifies the requirements of Active Harmonic Filters (AHF) for low-voltage applications, designed to reduce total demand distortion (TDD) and total harmonic distortion (THD) to levels less than 5%. The AHF shall also be able to correct for linear displacement and to balance the incoming three-phase current.

a) References, Codes, and Standards

1. ANSI/IEEE 519-2014: Guide for Harmonic Control in Electrical Power Systems.
2. ANSI/IEEE C62.41- 1991: Guide for Surge Voltages in Low AC Power Circuits.

b) Performance Requirements

- Harmonic Spectrum Cancellation from 2nd to 51st order, discrete, fully selectable per harmonic order, with Reactive Power Compensation 0-Lag to 0-Lead and Load Balancing.
- IGBT, 3 level Invertor Technology, Operating Temperature: up to 45^{0}C ambient, %THD_i and %THD_v setpoints should be settable, Control Response time 25 microsecond, AHF main Controller shall have Modbus system, with 7inch HMI Graphical Display and other technical specifications as per below.

Sr No.	Description	Requirement
1.	Standard Current rating	As per design at 415V AC
2.	Nominal Voltage	+ 10% / - 15%
3.	Nominal frequency	50 Hz ± 5%
4.	Number of Phases	3 Phase with neutral
5.	Power Electronics	3 Level IGBT
6.	Efficiency	> 97%
7.	Response Time	< 25 micro sec
8.	Spectrum cancellation	2nd to 51st, discrete; fully selectable per Harmonic order (amplitude and ON/OFF)
9.	Operating temperature	Design at Ambient 45 ^{0}C.
10.	Relative Humidity	95%, non-Condensing.
11.	Cooling	Forced Air.
12.	Cable Entry	Top
13.	Enclosure Protection	IP 52.
14.	Noise at 1m from panel front (ISO 3746)	< 70 db.
15.	User Interface	Touch screen HMI.
16.	Communication Interface	RS 485 Modbus / Modbus TCP / IP.
17.	Protection	MCCB & fast acting semiconductor fuses.
18.	Alarms	DC over voltage, overload trip, over temperature, over current, mains abnormal, filter trip, DC over voltage.
19.	Functions	Harmonic Filtering, power factor correction, load balancing.
20.	Reference Design Standard	IEC 60146
21.	Reference standard	IEC 61439-1, IEC 61000-6-2:2016 Class A, EN 61000-6-2, IEC 62477-1:2012, IEC 60146, EN 55011 Class A, EN 50178, JB/11067:2011

12.5.18 110V DC Power Supply

110V DC Power supply shall be provided for protection and control in 11kV and 415V Switchgears for Substation Buildings.

A Conventional system operating at 110V DC using maintenance free rechargeable Ni-Cd batteries shall be provided and shall be complete with battery, battery charger with boost & trickle charging facilities, necessary controls, indications, and DC distribution board.

12.5.19 Cabling

(a) 11kV Power Cables

The cables shall be 3 core, 11kV (UE), XLPE type with stranded aluminium conductors & GI armouring. The minimum size of cable shall be selected based on the short-circuit considerations.

(b) LV Power Cables

LV power cables shall be 1.1kV XLPE type with stranded Aluminium Conductors with GI armouring for sizes above 6 sq.mm and stranded copper conductors with GI armouring for sizes 6 sq.mm and below. No. of cores shall be as per requirement.

(c) Control Cables

Control cables shall be 650/1100V, XLPE with stranded copper conductors and GI armouring. No. of cores shall be as per requirement. Minimum size of core shall be 1.5 Sq.mm.

(d) Lighting & Power Circuits:

Class 2 copper conductor satisfying the resistance requirements of NEC 2023 Part 1 Section 17, Annex B

(e) Cable Rating

All power cables shall be sized for continuous current carrying capacity and permissible voltage drop at an ambient temperature of 45 degrees C. Due consideration shall be taken of cable grouping, method of installation and local variations in ambient conditions. Further, for cables controlled by circuit breakers, due consideration shall be given to the fault level.

MV and LV cables shall be sized for a minimum fault clearance time of

- 1 second for incoming feeders
- 0.5 second for tie feeders
- 0.25 second for motor feeders
- 0.16 second for transformer feeder

For all LT Cables, the voltage drop in the cables between the transformer and the switchgear (PCC panel) or between PCC panel and MCC panel for full load current shall be limited to 2%. Further the voltage drop in cables between PCC/MCC to Motor terminals for full load current shall be limited to 3%. The Total Voltage drop transformer secondary to motor terminal shall be limited to 5%.

Under motor starting conditions the corresponding voltage drop shall not affect the operation of the motor controls or the ability of the motor to start and run effectively and in any event shall not exceed 10%. The Contractor when sizing cables for the remote operation of shunt trip coils shall take due account of the voltage drop caused by the momentary current surge taken at the instant of energisation.

(f) Cable Installations

Inside the electrical room/substation/Building/Pump House (Except buildings like Office/Employers Bldg./Guard Room/Admin Bldg.)

Cables shall be routed on overhead cable tray with heavy duty galvanized iron cable tray (in chlorine, chemical and other corrosive areas, FRP/GRP type cable tray shall be used) and ladder racking shall be used for cable support systems with recommended bending radius as per relevant BIS standards. Cable trays shall be used to route cables along walls, below beams and within cable trenches. Cable trays shall be sized considering 20% margin. Cables shall be securely fixed to the support systems. Bundling of cables shall be permitted where allowance for this practice has been made while sizing the cables.

Inside the buildings like Office/Employers Bldg./Guard Room/Admin Bldg.

Cables shall be routed in conduit. Separate conduits shall be used for lighting circuits, power circuits & fan circuits. Separate conduits shall be provided for routing of wires of different phases.

Outside the Building/Pump House

All cable installations outside the plant area upto the building entrances shall be done in direct buried underground cable trenches as per IS 1255/NEC 2023. Necessary cable pull pit shall be provided at the entry/exit points of the building.

Road Crossing

Cables at road crossing shall be installed in RCC Ducts with a minimum cover of 1000mm from top of road level. There shall be cable pull pits connecting the RCC duct at either ends of the road crossings.

Street / Road Lighting

All cable installations for street / road lighting shall be direct buried underground cable trenches as per IS 1255/NEC 2023 at minimum depth of 750mm.

Cables of different categories shall be installed in separate trays and maintain satisfactory clearances for safety and to reduce the possibility of electrical interference. The following Table details the distances in mm that shall be maintained between the different categories of cables.

Table of Separation Distances between different Categories of Cable.

Cable Category	MV Power	LV Power	C&I/Protection
MV Power	Not specific but shall suit de-rating factor	300	600
LV Power	600	Not specific but shall suit de-rating factor	300
C & I / Protection	600	300	Not specific but shall suit de-rating factor
Gas/Water main	300	300	300

(g) Cable Numbering

All cables shall be allocated a unique number which shall be fixed to each end of the cable using a corrosion resistant label. Cables of different categories shall be tagged with the following subscripts and a three-digit number.

- MV power MV-P_ _ _
- LV power P_ _ _
- Control C_ _ _
- Instrumentation I_ _ _
- Protection PR_ _ _
- Telecommunication T_ _ _

12.5.20 Building Services

(a) Lighting

All internal and external areas shall be provided with LED lighting (minimum efficacy of 100 lm/w). Corrosive proof lights shall be considered in Battery Room. The illumination levels to be achieved shall be as follows:

Illumination System

Latest version of related IS standards, NBC (National Lighting Code), National Lighting Code (NLC) and relevant international codes shall be referred for designing Illumination for different areas.

All lighting design shall be carried out on DIALux latest version or OEM specific software.

The basis of design shall be based on the following lighting engineering criteria, as per relevant standards or specified herewith:

a) Lighting lux level

b) Luminance distribution

c) Glare restriction

d) Direction of incidence of light and shadow effect

e) Colour appearance and colour rendering of the light source

f) Uniformity

Selection of Luminaries and Illumination Level:

The following luminaries shall be provided for various areas in order to achieve the average luminance as per various relevant lighting standards or those indicated below:

Sl. No.	Area	Type of Light Fittings	Lux
1	Pump house	Surface Mounted Industrial LED batten / Low or Medium or High Bay LED	250 Lux
2	Battery room	Industrial type LED batten (Corrosion proof)	150 Lux
3	Machinery service area	Industrial type LED batten	250 Lux
4	Offices and conference rooms	LED Surface mounted decorative down lighter fitting with polycarbonate cover	300 Lux
5	Switchgear room/MCC, DG room	Industrial type LED batten	250 Lux
6	Control rooms/ SCADA room	LED Surface mounted decorative down lighter fitting with polycarbonate cover	300 Lux
7	Chemical and general stores	Industrial type LED batten	150 Lux
8	Chemical plant room	Anti-corrosion Industrial LED batten	250 Lux
9	All other indoor areas	Industrial type LED batten	100 Lux
10	Outdoor platforms and walkways	LED Bollard post tops and Uplighter	50 Lux
11	Building entrance	LED Surface mounted decorative down lighter fitting with polycarbonate cover	100 Lux
12	Outdoor plant areas	LED Flood lights	20 Lux
13	Outdoor transformer yards - General - On equipment	Industrial type LED batten	 20 Lux 30 Lux
14	Roads (secondary)	Industrial type LED batten	20 Lux

Energy Efficient Ceiling fans with BEE Star labelled of BLDC type shall be provided in offices, control rooms and they shall be connected to local lighting circuit.

The internal lighting installation shall be installed using single core, PVC insulated copper cable enclosed in galvanized iron / PVC conduit. Lighting in external areas shall be installed using multicore armoured cable.

Conduits shall be

For Plant Buildings & Pump House:

Surface Exposed uPVC Conduit on ceiling with vertical drops as below

- Plant RCC Building - Concealed uPVC conduit for drop down from ceiling to switch/socket level.
- Pump House – Surface uPVC conduit for drop down from ceiling to switch/socket level.

Control Building:

- Rooms with False ceiling – Surfaced uPVC conduit above ceiling & concealed uPVC conduit for drop down.
- Rooms Without false ceiling- Surfaced uPVC conduit on ceiling & concealed uPVC conduit for drop down.

Office Building:

- Concealed uPVC conduit in ceiling and vertical drop down.

Following factors shall be considered while arriving at the utilization factor to determine the number of fixtures for each area/building:

a) Maintenance Factor
   - Indoor Area Lighting with LED Luminaire : 0.7
   - Outdoor Area Lighting with LED Luminaire : 0.6

b) Reflection factor for Indoor Lighting to be considered are as follows:
   - Ceiling : 0.5
   - Walls : 0.3
   - Floors : 0.1

c) However, Reflection factor can be selected based on the Color of the wall and Ceiling as given below:
   - White and very light colors : 0.7
   - Light colors : 0.5
   - Middle tints : 0.3
   - Dark colors : 0.1

d) Room index at applicable surface reflection factors need to be considered.

e) The working plane shall be considered at 0.75 m from the floor level.

f) Uniformity factor shall be considered as per National Lighting code/ NBC/ IS code.

The power supply for lighting shall be distributed from Lighting Distribution Boards and feeder pillars.

For street lighting, cabling shall be done with 4C armoured cable such that alternate fixtures are in different phases.

(b) Emergency Lighting

Self-contained chargeable type emergency luminaires shall be provided to maintain minimum illumination level of 5 lux. These luminaires shall automatically illuminate in the event of a power failure and provide a minimum level of lighting for approximately 3 hours. They shall automatically recharge on the return of mains power.

Emergency lighting shall be provided outdoor, on platforms and inside buildings, using integral batteries. The emergency lights shall be strategically located along pre-defined escape routes from various areas.

(c) Ventilation & Exhaust Fans (3 phase)

Variable speed ventilation ceiling fans & exhaust fans shall be provided in offices and switchgear rooms as per requirement. One BEE star rated energy efficient Ceiling fan of 48" size shall be provided for each 10 m^2 or part thereof of the area concerned. Ceiling fans shall be connected to the local lighting circuit.

(d) Small Power Outlets

Switched single phase three pin 6 A and 16A receptacles shall be provided throughout. In offices and control rooms they shall be modular decorative type and industrial type in all other areas for single and three phase sockets. All outlets for domestic pump, dewatering pump, submersible sump pump shall be provided with local starter panel or control cubicle. All metal clad sockets shall be provided with suitable metal clad plug.

Unless required to be provided in greater numbers to power specific Plant items the number of such outlets shall be as follows:

- 6 A type one outlet per 5 m or part thereof of perimeter in offices and laboratories
- 6 A type one outlet per 20 m or part thereof of perimeter in all other areas
- 16 A type one outlet per 20 m or part thereof of perimeter in offices and laboratories
- 16 A type one outlet per 20 m or part thereof of perimeter in all other areas.

Emergency 6/16A Convenience socket outlets fed from ELDB (fed from UPS) shall be provided in

- Reception areas
- Control Room
- Engineering Room
- Meeting Rooms

(Note: All DCS/SCADA/communication Process related design shall be using UPS power)

(e) 3-Phase Power Outlets

32A switched (MCB) three phase and neutral receptacles shall be provided in plant areas where appropriate i.e., adjacent to areas where flooding is likely (to permit the use of portable sump pumps) or where other portable equipment is likely to be used in the operation of the treatment plant. Ten such outlets at various locations throughout the treatment plant shall be considered.

The location of outlets shall be approved by the Engineer. The spacing of 6A and 16A outlets shall be arranged to suit the intended location of equipment, desks etc.

Receptacles for outside areas shall have a degree of protection of IP 65.

12.5.21 Earthing & Lightning Protection

a) The earthing system shall be designed according to IS 3043, NEC 2023, NBC 2016, IEEE 80, BS 7354, 7430 or relevant IS/IEC standards.

b) Earthing system shall be a designed arrangement of an interconnected mesh of suitable size of earth conductors and electrodes buried below ground at the depth mentioned in IS 3043-2018 and connected to all the metallic exposed and accessible to humans but not intended to carry normal current, parts of the equipment which are vulnerable to live accidentally, which would cause irreparable damage to the equipment and danger to human life, if remain live at high potential beyond a certain safe period.

c) Earth grid shall provide

- An equipotential surface to limit the potential gradient at the Earth's surface.
- A low impedance path for the fault current to the earth, thereby avoiding a rise of potential to a dangerous level and ensuring fast clearance of earth faults by protective devices.

d) An earthing system comprising earth electrodes and conductors shall be established separately for each building / structure and these networks shall be interconnected.

e) Earthing installation inside a building shall be carried out by equipotential bonding with Main Earthing Terminal (MET). All the external earthing terminals of the switchboards/distribution boards (or) MET of the switchboard/distribution board; all protective conductors of exposed conductive parts are connected to Main Earthing Terminal (MET). All extraneous conductive parts, incoming metallic service pipes, are also connected to main MET. Furthermore, this main MET is connected to earth electrodes via the Earth conductor, as per the design of the supply system.

f) The earthing system shall be designed to give a combined earth resistance value of not greater than 1 ohm. To ensure obtaining suitable final values, soil resistivity shall be measured and recorded at various site locations during the detailed design phase of the work.

g) In outdoor substation areas where the main earth electrode conductors will be located, ensure potential gradients occurring at the surface during fault conditions are kept within allowable limits.

h) In outdoor transformer yards, substations & switchyards, crushed rock (min. 10 cm) or gravels (50mm size) in entire area shall be provided to increase contact resistance between person's foot and earth surface and thus provide safer step and touch potentials.

i) Along with the main grid conductors, sub-grid conductors and risers for equipment earthing shall be prepared and laid at proper locations. Depth of the earthing conductor shall be at least 600mm below final grade level (FGL). Earthing conductors around buildings shall be buried at 1.5m from outer boundary of the buildings. In outdoor yards & switchyards, main earth conductor shall be buried 1.0 m outside the fencing perimeter.

j) Earth conductor entering a building at below grade level, water stop shall be provided to avoid any seepage of water inside the building. Connections from the earth grid to the equipment shall be made using short, direct leads that are free from kinks and splices.

k) Earthing conductor embedded in concrete shall have at least 50mm concrete cover. Earth conductor shall be passed through Hume pipes for road crossings.

l) Light fixtures, conduits, ceiling fans, switches, sockets, power receptacles, JBs, streetlight poles, panels shall be earthed with separate earth conductor. RCCB/RCD (30 mA sensitivity) shall be provided in lighting circuits.

m) Connection between main grid and equipment earthing grid and between main grid/sub-grid conductors shall be welded or brazed type. Steel to copper and copper to copper connections shall be brazed type. Steel to steel connection shall be done by electric arc welding with low hydrogen

content electrode. For prevention of rust the welds or brazed connections shall be treated with Red Lead and thickly coated with black bituminous paint/compound. All brazing shall be done with oxy-acetylene torch flame.

n) Metallic sheaths, screen and armour of all multicore power/control cables shall be earthed at both, equipment, and source/switchgear ends.

o) Earthing of Computer and Electronic System: Safety earthing and zero signal reference ground should be provided for computer and electronic systems as per BIS code/approved specification/drawings.

p) Earth conductor crossing through wall or floor slab shall be routed in GI conduit or HDPE pipe sleeve. These sleeves shall be waterproof/bitumastic compound or by fireproof sealant.

q) Materials used for earth electrodes shall be designed to suit the ground conditions and shall be either plain mild steel or galvanized steel or copper coated steel.

r) All the electrical equipment, frames and mechanical apparatus shall be provided with designated grounding points. Cable trays and vertical runs shall be connected to earth grid at least 20-meter intervals.

s) The size of the earthing leads shall be dependent on the type of equipment, maximum let through ground fault current, fault clearing time of protective device connected to it.

t) The system shall be designed for the following maximum earth fault currents. These values shall be verified at detail design phase based on the short circuit calculations in ETAP software.

- 11 kV system 26.3 kA
- 415 V system 50 kA

u) The fault clearing time shall be considered as per IS 3043 with minimum one second for the 11 kV and 415 V systems.

v) The maximum temperature allowed for steel welded / brazed joints will be taken as 500 ^{0}C with an ambient of 45 ^{0}C. Main equipotential bonding conductors shall be galvanized steel.

w) Circuit protective conductors will comprise either the armouring of the supply cable or, for major loads such as main switchboards and large drives the supply cabling plus an additional suitably sized single core copper cable.

x) The neutral point of the 11/0.433 kV transformer secondary windings will be solidly earthed.

y) The need of lightning protection shall be established by calculating the overall risk factor as per IS/IEC 62305.

z) Air termination system comprising of rods/mesh or combination of both shall be provided and the methods used to determine the positioning of Air termination system shall be as per IS/IEC 62305.

aa) Air termination system shall be connected to the earthing system by down conductors fixed along the outer surface of building. Number & layout of the down conductors shall be as per IS/IEC 62305.

bb) Each down comer will be terminated to a separate treated test earth electrode which in turn will be connected to plant earthing system.

cc) A test link will be provided at approximately 1000 mm above ground level for each down conductor during the run.

12.6 Safety Procedures

All Electrical work design, installation, testing and commissioning shall be strictly followed as per

a) Central Electricity Authority (Measures relating to Safety and Electric Supply) Regulations 2023.

b) National Electrical Code of India 2023, part 1 section 22.

- A comprehensive power distribution schematic diagram for the entire plant area shall be prepared, and based on additions/ alterations, such diagrams should be updated from time to time.

- Premises like transformer yard, sub-stations, electrical rooms, pump house, generating rooms, etc. shall be kept clean, free from the growth of plant vegetation, storage of broken furniture, dismantled materials, waste material, packing boxes, etc.

- All premises like sub-station, pump house etc. to be maintained as protected area with admission allowed to authorized persons only. Also, the access of such areas shall be kept free and parking.

- No inflammable materials shall be stored in places other than the rooms specially constructed for this purpose following the provisions of the Indian Explosives Act.

- Rubber or insulating mats as per IS: 15652:2006 should be provided in front of the main switchboards or any other control equipment of medium voltage and above.

- Protective and safety equipment such as rubber gloves, earthing rods, safety belt, portable artificial respiration apparatus etc. should be provided in each sub-station, admin building, guard room and important installations. Where electric welding or such other nature of work is undertaken, goggles shall also be provided.

- Necessary number of caution boards such as "Men ON LINE ", "Don't Switch ON" should be readily available in each sub-station, admin building and important installations.

- Standard first aid boxes should be provided in each sub-station, guard room and important installations and should be readily available.

- Periodical examination of the first aid facilities and protective and safety equipment provided at the various installations shall be undertaken for their adequacy and effectiveness and a proper record shall be maintained.

- Charts (English/Kannada) displaying methods of giving artificial respiration to a recipient of electrical shock should be prominently displayed at appropriate places.

- A chart containing the names, addresses and telephone numbers of the nearest authorized medical practitioners, hospitals, fire brigade and also of the officers in executive charge shall be displayed prominently along with the First Aid Box.

- Electrical wiring and control switches should be periodically inspected and any defective wiring, broken parts of switches which will expose live parts, should be replaced immediately to make the installations safe for the user.

- The electrical switchgears and distribution boards should be clearly marked to indicate the areas being controlled by them.

12.7 Load and Electricity Consumption Calculation

Plant electrical load list shall be developed, for each MV/LV switchgear/MCC based on details available at various stages of project. The bidder shall submit the preliminary load list sheet along with bid. The load list shall be updated on regular basis during the design stage of the project and shall form the basis for provision of the transformer and diesel generators capacity.

The load list shall include and identify the following minimum details:

- Continuous, intermittent, and standby loads
- Normal, & critical (AC UPS, DC, or emergency) loads
- Load and diversity factors, power factors of individual loads, efficiencies of electrical equipment, like motors; and
- Starting method (Power Feeder, DoL/Star Delta/VFD/Soft starting etc.)
- Continuous Working load (kW/kVA) and Peak Working load (kW/kVA) for individual loads and total plant.

The peak loads calculated from this load list form the basis for various equipment sizing like transformers, switchgears, DG set, UPS, cables etc.

A summary sheet must be included in the load list, detailing loads at various switchboards (PCC/MCC/DG PCC), DG, and transformer ratings. Typical electrical load list format is provided below for reference

Typical Electrical Load List Format

ELECTRICAL LOAD LIST FORMAT - WwTP / ISPS

S.No	Load Description	Total Quantity	Working Qty	Standby Qty	Capacity	Head	Specific gravity	Pump Efficiency	Unit Load	Motor Efficiency	Motor KW with Margin	Selected Motor kW	Working Hours	Total Working Load	Total Standby Load	Motor Speed	Voltage	Mounting	Type of Pump	Type of Service (Continuous/Intermittent)	Type of Starting	Electrical Drive Type(Constant Speed/Variable Speed)	Total Energy Consumption per Day
		Nos	Nos	Nos	m3/hr	m		%	bkW	%		kW	Hrs	KW	KW	rpm	V						kWh/Day
Process Unit -1																							
a	Load-1	4	3	1	-	-	-	-	1.87	-	-	2.20	8.00	5.61	1.87	1440	415	-		I	VFD	Variable (VFD)	
b	Load-2	1	1	0	-	-	-	-	0.94	-	-	1.10	8.00	0.94	0.00	1440	415	-		I	DOL	Constant	
c																							
d																							
e																							
f																							
Process Unit -2																							
a	Load-1	4	3	1	-	-	-	-	1.87	-	-	2.20	8.00	5.61	1.87	1440	415	-		I	VFD	Variable (VFD)	
b	Load-2	1	1	0	-	-	-	-	0.94	-	-	1.10	8.00	0.94	0.00	1440	415	-		I	DOL	Constant	
c																							
d																							
Miscellaneous Loads																							
a	Lighting Load (Indoor)	1	1	0	-	-	-	-	80.00	-	-	80.00	16.00	80.00	-	-	415	-	-	C	MCCB	-	
b	Lighting Load (Outdoor)	1	1	0	-	-	-	-	80.00	-	-	80.00	16.00	80.00	-	-	415	-	-	C	MCCB	-	
c	Instrumentation Load (SCADA, PLC, UPS etc.)	1	1	0	-	-	-	-	5.00	-	-	5.00	-	5.00	-	-	415	-	-	C	MCCB	-	
d	Laboratory Load	1	1	0	-	-	-	-	5.50	-	-	5.50	24.00	5.50	-	-	415	-	-	C	MCCB	-	
e	Socket Loads																						
f	Additional Loads	1	1	0	-	-	-	-	40.00	-	-	40.00	-	40.00	-	-	415	-	-	-	-	-	
Total														**223.59**	**3.74**								**0.00**

12.8 Technical Particulars of MV Metal Enclosed Switchboard / MV VCB Panel

Sr. No.		Description	Unit	Technical Particulars
12.8.1		Make		As per Preferred Makes/ Manufacturers of Part-6, General requirement.
12.8.2		Type		As per Specification
12.8.3		Applicable Standards		As per Specification
12.8.4		Quantity	No.	(*)
12.8.5		**Switchgear cubicles and Bus bar ratings**		
	(a)	Rated voltage, phases, and frequency		11kV, 3 phase, 50 Hz
	(b)	System Neutral Earthing		Resistance earthed
	(c)	Maximum system voltage	kV	12
	(d)	One-minute power frequency withstand voltage	kV (rms)	28
	(e)	12/50 µsec impulse withstand voltage	kV (peak)	75
	(f)	Short circuit withstand		
		(i) Short time (1 sec) at rated voltage	kA (rms)	26.25
		(ii) Dynamic rating	kA(peak)	65
	(g)	Reference ambient temperature	°C	45°C
	(h)	Maximum temperature of bus bars droppers' connectors and contacts at continuous current rating under site reference ambient temperature	°C	Non-silver-plating Joints: 90 °C Silver plating joints: 105 °C
	(i)	Continuous current rating of bus bar	A	(*)
	(j)	Bus bar material		Copper
	(k)	Bus bar Insulation		Fully insulated by encapsulation in epoxy resin with mould caps protecting all joints
	(l)	Cable entry		Indoor Panel (Top) / Outdoor Panel (Bottom)
	(m)	Cable type for Incoming and Outgoing feeders		11kV (UE), XLPE Aluminium conductor with GI armouring
12.8.6		**Switchgear constructional Requirement**		
	(a)	Thickness of sheet steel Frame, Frame enclosures, doors, covers and partitions	mm	Frame – 2.5 minimum, Doors/Covers/partitions –2.0 minimum Gland plate-3 mm

Sr. No.		Description		Unit	Technical Particulars
	(b)	Degree of protection			IP4X for panel enclosure & busbar & IP52 for metering compartment.
	(c)	Colour finish shade			Interior - Glossy white Exterior – RAL 7035
	(d)	Earthing bus	i) Material		Copper (run throughout the panel)
			ii) Size	mm x mm	(*)
	(e)	Earthing conductor	i) Material		GS Flat
			ii) Size	mm x mm	(*)
12.8.7		**Breaker Particulars**			
	(a)	Circuit breaker type			3 pole, Vacuum draw out type, truck mounted with Surge Suppressor, trip free mechanism & anti pumping feature
	(b)	Voltage, phases, and frequency			12 kV, 50 Hz, 3 Ph
	(c)	Rated operating duty			O – 0.3 sec. – CO – 3 min - CO
	(d)	Rated current at reference ambient temperature (i) Incoming breakers		A	(*)
		(ii) Outgoing breakers		A	(*)
	(e)	Rated breaking capacity		kA (rms)	26.25
	(f)	Rated making current		kA (peak)	65
	(g)	Short time current withstand for 1 sec duration		kA (rms)	26.25
	(h)	Total break time		milli seconds	Less than 50
	(i)	Operating mechanism type (Normal)			Motor spring Charged stored energy type for closing and tripping
		Operating mechanism type (Emergency)			Manual Spring Charged for closing and tripping
	(j)	Minimum no. of auxiliary contacts			6 NO+ 6 NC
	(k)	Withstand test voltage			
		(i) One-minute power frequency		kV (rms)	28
		(ii) 1.2/50 μ sec impulse		kV (peak)	75

Sr. No.		Description	Unit	Technical Particulars
	(l)	Auxiliary control voltage (i) For closing / tripping coil		110 V DC
		(ii) For spring charging motor		240 V AC
		(iii) For space heaters and lighting		240 V AC
		(iv) Permissible variation in operating voltage of closing & tripping coils		85 to 110% for closing coil 70 to 110% for tripping coil
	(m)	Anti-pumping feature		To be provided
	(n)	Latching requirement		Trip free
12.8.8		**Current Transformers**		
	(a)	Type		Cast resin window type
	(b)	Class of insulation		Class E or better
	(c)	Rated current ratio and burden (i) Incomers and bus couplers		(*)
		(ii) Outgoing feeders		(*)
	(d)	Accuracy class (i) Metering		1.0
		(ii) Protection		5P20 and PS for core connected to Restricted Earth fault relay
	(e)	Short time 1 sec current rating	kA (rms)	26.25
	(f)	Dynamic rating	kA (peak)	65
12.8.9		**Voltage Transformers**		
	(a)	Type		Cast resin
	(b)	Rated Voltage (i) Primary	V	11000/√3
		(ii) Secondary – S1	V	110/√3, 110/√3
	(c)	Method of connection (i) Primary – P		Star, earthed
		(ii) Secondary – S1		Star, earthed
	(d)	Application – S1		Metering and protection
	(e)	Rated burden	VA	(*)
	(f)	Accuracy class		Metering 1.0 Protection 3P
	(g)	Rated voltage factor (i) Continuous		1.2
		(ii) Short time		1.5
	(h)	Insulation class		Class E or better
12.8.10	(a)	**Meters** Make		As per Preferred Makes/ Manufacturers of Part-6, General requirement.
	(b)	Accuracy Class		
12.8.11		(i) Indicating Meters		Class 1.0 or better
		(ii) Energy Meter		Class 1.0 or better
12.8.12		**Protective Relays**		
		Type		Numerical Type

Sr. No.	Description	Unit	Technical Particulars
	Auxiliary supply		110V DC
12.8.13	**Annunciations**		
	Annunciations for Metal enclosed Switch board		
(a)	Following alarm annunciation shall be provided on the 11kV Metal Enclosed Switchboard Incoming feeders (i) Tripped on fault (ii) O/C&E/F operated (iii) Trip circuit supervision unhealthy (iv) DC fail (v) AC fail		
(b)	For each Outgoing transformer feeder circuit breakers (i) Tripped on fault (ii) O/C&E/F operated (iii) Buchholz, WTI, OTI trip (iv) Trip circuit supervision unhealthy (vi) DC fail (v) AC fail (vi) Buchholz, WTI, OTI, Oil level low alarms		
(c)	For Other Outgoing feeders (i) Tripped on fault (ii) O/C&E/F operated (iii) Trip circuit supervision unhealthy (iv) DC fail (v) AC fail		
(d)	For Bus PT (i) Under voltage trip (ii) DC fail (iii) AC fail		
(e)	Spare windows: 2 Nos. Minimum.		
12.8.14	**Cubicle Components**		
	Each 11kV circuit breaker cubicle shall be provided with the following minimum standard accessories		
(a)	One control switch 'trip-neutral-close' spring return to neutral position		
(b)	One control selector switch 'Local-Off-Remote stay-put' type		
(c)	LED Indicating lamps (i) 'Red' for breaker in 'On' indication (ii) 'Green' for breaker 'Off' position (iii) 'Amber' for breaker tripped on fault 'White' for trip circuit healthy (iv) 'Blue' for breaker in 'Service' position (v) 'White' for breaker in 'Test' position (vi) 'Blue' for breaker spring 'Charged' (vii) 'Amber' for DC fail (viii) 'Amber' for AC fail (ix) 'Red,' 'Yellow,' 'Blue' for supply healthy for incomers. (x) 'Yellow" for 'Ready to close'		

Sr. No.	Description	Unit	Technical Particulars
(d)	Mechanical trip push button to trip the breaker when control supply is lost. The push button shall be shrouded type		
(e)	One electrical anti-pumping relay		
(f)	Double pole control supply MCB one each for AC & DC control supply		
	Cubicle space heater of adequate capacity with thermostat		
(g)	240V, 1 Phase, 50Hz, 15/5A, 5 pin receptacle with switch		
(h)	Cubicle lamp with door interlock switch		
12.8.15	**Auxiliary A.C. Supply**		
	240V, 1Ph, 50Hz supply shall be made available to each cubicle of 11kV Metal Enclosed Switchboards separately for provision of following by providing control transformer		
(a)	Spring charging motor		
(b)	Cubicle space heater with thermostat		
(c)	Cubicle lamp		
(d)	240V, 1Ph, 50Hz 15/5A 5 pin receptacle with switch		

12.9 Technical Particulars of Distribution Transformers

Sr. No.	Description	Unit	Technical Particulars
12.9.1	Make		As per Preferred Makes/ Manufacturers of Part-6, General requirement.
12.9.2	Type		As per Specification
12.9.3	Applicable Standards		As per Specification & IS 1180 latest amendment
12.9.4	Rated output	kVA	(*)
12.9.5	Quantity required	Nos.	(*)
12.9.6	Transformer location		Outdoor
12.9.7	No load transformer ratio	kV/kV	11/0.433
12.9.8	Number of phases		3
12.9.9	Rated frequency	Hz	50
12.9.10	Impedance at all taps Standard losses	% Watts	Value as per IS 1180 Latest Amendment-4, EEL-2
12.9.11	Number of winding / materials of conductor / Insulation class		Two/Copper/class A
12.9.12	Method of connection		
(a)	MV winding		Delta
(b)	LV winding		Star
12.9.13	Vector group		Dyn11
12.9.14	LV Neutral		Solidly earthed
12.9.15	Type of cooling		ONAN

Sr. No.	Description	Unit	Technical Particulars	
12.9.16	Tap changer		Full capacity, microprocessor base On-load type on MV side with local marshalling box and Remote Tap Changing panel	
12.9.17	Tap range	%	+ 5 % to -15 %	
12.9.18	Tap step	%	2.5 %	
12.9.19 (a) (b)	Terminal connection MV terminals LV terminals		Cable box suitable to 11kV UE, XLPE, Al. Conductor, armoured cable of size (*) Cable box suitable for 1100V XLPE, Al. Conductor armoured cables (*) For transformer ratings greater than or equal to 1000kVA, LV side should be suitable for termination of Non-Segregated Aluminium Bus duct (*)	
12.9.20 (a) (b)	Current Transformer On LV On LV Neutral		(*)	
12.9.21	LV Neutral earthing		The neutral of the star-connected winding shall be brought out to a separate bushing terminal. The neutral bushing shall be provided on the tank side to facilitate lead of the earth conductor (*) down to the ground level. For transformers 1000 kVA and above, tank mounted Epoxy resin cast insulators shall be provided for supporting the neutral earthing bar of required section, along its run from the neutral bushing to ground-level. Neutral shall also be extended to cable box /bus duct flange as applicable.	
12.9.22	Insulation of Windings		H.V.	L.V.
(a)	One-minute power frequency withstand voltage (dry and wet)	kV (r.m.s)	28	3.0
(b)	1.2/50 microsecond full wave impulse withstand voltage	kV (peak)	75	-

Sr. No.	Description	Unit	Technical Particulars	
12.9.23	Insulation of bushings		H.V.	L.V. (Line and Neutral)
(a)	Rated Voltage of bushing	kV	17.5	1.1
(b)	One-minute power frequency withstand voltage	kV (r.m.s)	38	3.0
(c)	1.2/50 microsecond full wave impulse withstand voltage	kV (peak)	95	-
(d)	Minimum creepage distance	mm	25mm/kV on 17.5kV	25mm/kV on 3kV
12.9.24	Vacuum withstand capability of transformer main tank with bushings, radiations, fitting and accessories.		As per IS 1180	
12.9.25	Inspection		As per IS 1180, Complete Routine test and one each from Type test and Special test to be indicated in QAP for witness	

12.10 Technical Particulars of 415 V Metal Enclosed Switchgears (PCC) /MCC

Sr. No	Description	Unit	Technical Particulars
12.10.1	Make		As per Preferred Makes/ Manufacturers of Part-6, General requirement.
12.10.2	Type		As per Specification
12.10.3	Applicable Standards		As per Specification
12.10.4	Quantity	No.	(*)
12.10.5	**415 V Switchgear and Busbar Ratings**		
(a)	Rated voltage phase and frequency		415V, 3 Ph, 50 Hz
(b)	System Neutral Earthing		Solidly earthed
(c)	Maximum system voltage	V	476
(d)	One-minute power frequency voltage		
	i) Power circuits	V	2500 (rms)
	ii) Control circuits	V	1500 (rms)
	iii) Aux. Circuits connected to Sec of CTs	V	1500 (rms)
(e)	Continuous current rating of Busbars under site reference	Rating Material	(*) Copper

Sr. No	Description		Unit	Technical Particulars
	Ambient Temperature and type & material			
(f)	Busbar insulation			Fully insulated encapsulation in epoxy resin with moulded caps protecting all joints
(g)	Reference Ambient Temperature		º C	45
(h)	Maximum Temperature of Busbars, Droppers and Contacts at Continuous current rating under site ambient temperature		º C	85 for busbars and non-silver-plated joints
				100 for silver plated joints
(i)	Short Circuit current withstand for Busbars and droppers (i) Short time 1 sec		kA (rms)	50
	(ii) Dynamic Rating		kA (peak)	125
12.10.6	**Switchgear Constructional Requirement**			
(a)	Type of Construction			Single front fixed type (Except for air Circuit Breakers, which shall be draw out type). Construction features shall be as per specification.
(b)	Thickness of sheet steel (i) Frame, Frame enclosures, doors, covers and partitions		mm	CRCA– 2.0
(c)	Degree of protection			IP 54 indoor and IP 55 for outdoor
(d)	Colour finish shade			Interior: Glossy white
				Exterior: RAL 7035
(e)	Earthing bus	Material		Copper (run throughout the panel)
		Size	mm x mm	(*)
(f)	Earthing conductor	Material		GS
		Size	mm x mm	(*)
(g)	Minimum clearances in air of live parts (i) Phase to Phase		mm	25.4
	(ii) Phase to Earth		mm	25.4
(h)	(i) Cable entry (ii) Cable entry for panels above wet well			Top

Sr. No	Description	Unit	Technical Particulars
12.10.7	**Instrumentation Transformers**		
(a)	Current transformer		
	(i) Ratio		(*)
	(ii) Burden	VA	(*)
	(iii) Accuracy Class		1.0
(b)	Voltage transformer		
	(i) Ratio		(415V/ √3) / (110V/ √3)
	(ii) Burden	VA	50
	(iii) Accuracy Class		1.0
(c)	Auxiliary A.C. Supply		240V, 1Ph, 50Hz supply shall be made available to each cubicle of 415V Metal Enclosed Switchboards separately by providing control transformer

12.11 Technical Particulars of Power Capacitor and Control Panel

Sr. No	Description	Unit	Technical Particulars
12.11.1	**General**		
(a)	Make		As per Preferred Makes/ Manufacturers of Part-6, General requirement.
(b)	Type		As per Specification
(c)	Applicable Standards		As per Specification
(d)	Quantity	No.	(*)
(e)	Rated Capacity	kVAR	(*)
(f)	Rated supply voltage	V	415
(g)	Rated frequency and phases		50Hz, 3Phase
(h)	Reference Ambient temperature	^{o} C	45
(i)	Cable gland required		Yes
(j)	Type of cable		1.1kV, XLPE, Al. Conductor
(k)	Size of cable		(*)
(l)	Cable entry		Top
12.11.2	**Constructional Requirement**		
(a)	Thickness of sheet steel i) Frame, Frame enclosures, doors cover and partition	mm	CRCA 2.0

Sr. No	Description		Unit	Technical Particulars
(b)	Degree of protection			IP 42
(c)	Colour finish shade			Interior: Glossy white
				Exterior: RAL 7035
(d)	Main busbars and size			Copper
(e)	Maximum Temperature of Busbars, Droppers and Contacts at Continuous current rating under site ambient temperature		^{o} C	85 for busbars and non-silver-plated joints 100 for non-silver-plated joints
(f)	Earthing bus	Material		Copper (run throughout the panel)
		Size	mm x mm	(*)
(g)	Earthing conductor	Material		GS
		Size	mm x mm	(*)
12.11.3	**Design Requirement**			
(a)	Insulation level		kV (rms)	3.0
(b)	Capacitor bank connection			Delta
(c)	Short circuit withstand for busbars i) short time (1 sec)		kA (rms)	50
	ii) Dynamic		kA (peak)	125
(d)	Type of switching			Automatic switching responsive to power factor through power factor sensing relay
(e)	Switching steps			Minimum 8 steps
(f)	Switch and Rating of contactor			To suit kVAR of unit (switching duty)
(g)	Incomer MCCB current rating			To suit rated capacity of capacitor banks (switching duty)
(h)	O/L capacity of capacitors			30% of rated capacity as per IS
(i)	O/V capacity of capacitors			10% of rated voltage as per IS
(j)	Protections			O/V, U/V and O/L

12.12 Technical Particulars of Diesel Standby Generator Sets

Sr. No.	Description	Unit	Technical Particulars
12.12.1	**General**		
(a)	Type		Silent Set with AMF
(b)	Sound Level at 1 metre distance		< 75 dB
12.12.2	**Alternator**		
(a)	Manufacturer		As per Preferred Makes/ Manufacturers of Part-6, General requirement.
(b)	Type		Salient pole, Revolving field, Brushless type
(c)	Rating	kVA	(*)
(d)	Voltage	V	415
(e)	Frequency	Hz	50
(f)	Overload Capacity		10% overload for 1 hour in any 12 hours
(g)	Insulation		Class H with Class F temperature rise
(h)	Short circuit current		3 times full load current for 10 sec
(i)	Degree of protection		IP 23 with IP 54 for terminal box
(j)	Current	A	(*)
(k)	Power Factor		0.8
12.12.3	**Diesel Engine**		
(a)	Manufacturer		As per Preferred Makes/ Manufacturers of Part-6, General requirement.
(b)	Type		Four stroke, direct injection, turbocharged
(c)	Rating	kW	(*)
(c)	Speed	rpm	1500
(d)	Fuel Specification		As per manufacturer's standard
(e)	Overload Capacity		10% overload for 1 hour in any 12 hours
(f)	Class of governance		Class A2
12.12.4	Day oil tank capacity with all necessary connections for fuel flow from day tank to DG engine with level sensors, inlet, outlet piping with valves and accessories etc. Complete	Litres	990 (DG Set rating less than 200kVA fuel storage shall require to run minimum 10 hours continuously)

12.13 Technical Particulars of Variable Frequency Drives

Sr. No.	Description	Unit	Technical Particulars
12.13.1	Make		As per Preferred Makes/ Manufacturers of Part-6, General requirement.
12.13.2	Type of Drive		Inverter Controlled A.C Drives
12.13.3	Rated voltage, frequency, and phases	V	415V, 50Hz, 3Phase
12.13.4	Variation in voltage	V	415V $\pm$ 10
12.13.5	Variation in frequency	Hz	50Hz $\pm$ 5
12.13.6	Type of Duty		100% continuous, 150 % overload for 2 minutes once in period of 24 hours, 200 % overload for 10 seconds once in period of 24 hours
12.13.7	Design Ambient Temperature	^{0}C	45^{0}C
12.13.8	Overall Harmonic Limitation (THD_i)		Less than 5% (including current and voltage harmonics)
12.13.9	Application		
12.13.10	Interfaces		Serial / Profibus

12.14 Technical Particulars of Battery

Sr. No.	Description	Unit	Technical Particulars
12.14.1	Make		As per Preferred Makes/ Manufacturers of Part-6, General requirement.
12.14.2	Type of battery		Ni-Cd
12.14.3	Applicable Standards		As per Specification
12.14.4	Number of battery banks required		(*)
12.14.5	Ambient conditions		Min. Temp. 25° C
			Max. Temp 45° C
12.14.6	D.C. system voltage	V	110 ±10%
12.14.7	Ampere hour capacity of battery at 27 Deg. C at 5-hour rate to give final cell voltage of 1.16 volts/cell	Ah	As per the Requirement
a	Momentary load/duration	A	To be furnished by the Bidder
b	Emergency load/duration	A	
c	Continuous load/duration	A	
12.14.8	Nominal voltage	V	1.2 V per cell
12.14.9	Cell voltage - initial/final	V	1.42/1.14 V
12.14.10	Number of cells per bank required to give rated voltage	Nos.	(*)
12.14.11	Number of spare cells per bank	Nos.	(*)
12.14.12	Mounting arrangement		Multi-tier
12.14.13	Charging method		Float cum boost charging

12.15 Technical Particulars of Battery Charger

Sr. No.	Description	Unit	Technical Particulars
12.15.1	**General**		
(a)	Make		As per Preferred Makes/ Manufacturers of Part-6, General requirement.
(b)	Applicable Standards		As per Specification
(c)	Type		Float and Float cum Boost Charge
(d)	Number required	Nos.	(*)
(e)	Rated Output voltage (DC)	V	110

Sr. No.	Description		Unit	Technical Particulars
(f)	Rated Output		kW	(*)
(g)	DC System Earthing			Unearthed
(h)	Voltage regulation from no load to rated load		%	± 1
(i)	Ambient Design Temperature		Deg C	45
(j)	AC ripple in DC output voltage at rated continuous load			Less than 1%
(k)	Type of rectifier			SCR, full wave fully controlled
(l)	Transformer			Copper double wound dry type with class-F insulation
(m)	Float/Trickle charging current of battery		mA	As per manufacturer
(n)	Boost Charging Current of Battery (Maximum)		A	As per manufacturer
(o)	Boost Charging Voltage of Battery (maximum)		V	As per manufacturer
(p)	Maximum Time for Boost charging of Battery		hr	As per manufacturer
12.15.2	**Battery Details**			
(a)	Float/Trickle charging current of battery		mA	As per manufacturer
(b)	Boost Charging Current of Battery (Maximum)		A	As per manufacturer
(c)	Boost Charging Voltage of Battery (maximum)		V	As per manufacturer
(d)	Maximum Time for Boost charging of Battery		hr	As per manufacturer
(e)	Battery capacity & no. of cells		Ah	(*)
			Nos.	(*)
12.15.3	**AC System Data**			
(a)	Supply	Voltage	V	415
		Phase		3
(b)	(i) Variation in supply Voltage		%	± 10
	(ii) Variation in supply frequency		%	± 5
(c)	Short Circuit level		kA	50
(d)	Type of earthing			Solidly Earthed
12.15.4	**Performance**			
(a)	DC voltage setting adjustment for			±10% of nominal voltage

Sr. No.	Description		Unit	Technical Particulars
	float charger			
(b)	Voltage stabilisation for constant voltage regulator			±1% of set D.C. voltage, with AC input variation and DC load variation from 0 to 100%
(c)	Maximum permissible variation in DC voltage (no load to full load)			± 1%
(d)	D.C. voltage setting adjustment for boost charging			70% to 100% of max. boost charging voltage
(e)	D.C. current adjustment for boost Charging			30% to 100% of max. boost charging current
(f)	Current stabilisation for constant current regulator for boost charger			± 2%
(g)	Minimum permissible power factor to rated continuous load			0.8
(h)	Permissible ripple content at rated continuous load			3% (maximum)
(i)	Relay for auto changeover from Float to boost mode to be provided (in case of float-cum-boost charger)			Yes
12.15.5	**Constructional Features**			
(a)	Thickness of sheet steel Frame, Frame enclosures, doors, covers and partition		mm	Cold rolled 2.0
(b)	Degree of protection			IP 42
(c)	Colour finish shade			Interior: Glossy white
				Exterior: RAL 7035
(d)	Earthing bus	Material		Copper
		Size	mm x mm	(*)
(e)	Earthing conductor	Material		As per Part 6
		Size	mm x mm	(*)
(f)	Cable entry			Top
(g)	Cable Sizes (i) Battery		sq.mm	(*)
12.15.6	(ii) DC output		sq.mm	(*)
12.15.7	(iii) AC input		sq.mm	(*)

12.16 Technical Particulars of DC Distribution Board

Sr. No.	Description		Unit	Technical Particulars
12.16.1	**General**			
(a)	Make			As per Preferred Makes/ Manufacturers of Part-6, General requirement.
(b)	Applicable standards			As per specification
(c)	Quantity		Nos	(*)
(d)	DC System voltage (Nominal)		V	110
(e)	DC System Earthing			Unearthed
(f)	Ambient Design Temperature		Deg. C	45
(g)	Busbar material, rating, and size			Copper, Rating & Size (*)
12.16.2	**DC Bus Load**			
(a)	Total continuous DC load		A	(*)
(b)	Short time loads (Additional to continuous loads)			
	(i) DC lights/Facia lamps		A	(*)
	(ii) Starting current and duration of Largest Connected DC Motor		A	(*)
			Secs	(*)
12.16.3	**Constructional Features**			
(a)	Thickness of sheet steel Frame, Frame enclosures, doors, covers and partition		mm	CRCA 2.0 min.
(b)	Degree of protection			IP 54
(c)	Colour finish shade			Interior: Glossy white
				Exterior: RAL 7035
(d)	Earthing bus	Material		Copper (run throughout the panel)
		Size	mm x mm	(*)
(e)	Earthing conductor	Material		As per Part 6
		Size	mm x mm	(*)
(f)	Cable entry			Top
(g)	Cable Sizes (i) DC Input from Battery		sq.mm	(*)
	(ii) DC output to Load		sq.mm	(*)

12.17 Technical Particulars of Cables

Sr. No.	Description	Unit	Technical Particulars
12.17.1	**11kV (UE) XLPE Insulated Power Cables**		
(a)	Make		As per Preferred Makes/ Manufacturers of Part-6, General requirement.
(b)	Applicable Standards		As per specification
(c)	Cable size selection		As per requirement
(d)	Continuous current rating with cable laid in air/ ground under specified ambient temperature	A	(*)
(e)	Conductor material		Stranded, aluminium, EC grade/class 2
(f)	Conductor screening		Semiconducting compound by extrusion
(g)	Insulation		Extruded XLPE
(h)	Screening on Insulation		Semiconducting compound by extrusion (non-metallic), copper tape (metallic)
(i)	Identification of codes		By providing strip of Red, Yellow & Blue colours
(j)	Inner sheath		Extruded PVC, type ST-2
(k)	Filler material		PVC
(l)	Armouring		Galvanised steel flat strip
(m)	Outer sheath		Extruded PVC, type ST-2
(n)	Overall diameter of cable		To be furnished by the Bidder
(o)	Recommended minimum bending radius	mm	To be furnished by the bidder
(p)	Standard length of cable on each drum	mts	(*)
12.17.2	**1100V Grade XLPE Insulated Power Cables**		
(a)	Make		As per Preferred Makes/ Manufacturers of Part-6, General requirement.
(b)	Applicable Standards		As per specification requirement
(c)	Cable size selection		As per specification
(d)	Conductor material		Stranded, aluminium/copper, EC grade
(e)	Insulation		XLPE
(f)	Inner sheath		Extruded PVC, type ST-2
(g)	Armouring		Galvanised steel flat strip/round wire
(h)	Outer sheath		Extruded PVC, type ST-2
(i)	Overall diameter of cable		To be furnished by the Bidder
(j)	Recommended minimum bending radius	mm	To be furnished by the bidder

Sr. No.	Description	Unit	Technical Particulars
(k)	Standard length of cable on each drum	mtrs	(*)
12.17.3	**650/1100V Grade PVC Insulated Control Cables**		
(a)	Make		As per Preferred Makes/ Manufacturers of Part-6, General requirement
(b)	Applicable Standards		As per specification
(c)	Rated voltage	V	As per requirement
(d)	Cable size selection		As per specifications requirement
(e)	Conductor material		Stranded, copper, EC grade
(f)	Insulation		PVC
(g)	Inner sheath		Extruded PVC, type ST-1
(h)	Armouring		Galvanised steel round wire
(i)	Outer sheath		Extruded PVC, type ST-1
(j)	Standard length of cable on each drum	mtrs	(*)

12.18 Technical Particulars of Lighting Fixtures and Accessories

Sr. No.	Description	Unit	Technical Particulars
12.18.1	**General**		
(a)	Make		As per Preferred Makes/ Manufacturers of Part-6, General requirement.
(b)	Type		As per specification
(c)	Illumination levels at various premises		As per Building Services, Clause 12.16 of Part 12- Particular electrical requirements
(d)	Normal supply voltage, phase, and frequency	AC	240V, 1Ph, 2 wire, 50Hz
		DC	110V, 2 wire, unearthed
(e)	Variation in supply:		
	(i) Voltage (AC & DC)	%	$\pm$ 10
	(ii) Frequency	%	$\pm$ 5
	(iii) Combined voltage & frequency	%	$\pm$ 10
(f)	Design ambient air temperature	^{0}C	45° C
12.18.2	Luminaire terminal suitable for		
(a)	Indoor area		

Sr. No.	Description	Unit	Technical Particulars
	(i) Conductor material		Copper
	(ii) Cable size	Coresxmm^2	(*)
(b)	Outdoor area		
	(i) Conductor material		Copper
	(ii) Cable size	Cores xmm^2	(*)
12.18.3	Luminary earthing terminal suitable for		
	(i) Conductor material		G. S. wire
	(ii) Conductor size	SWG	(*)

12.19 Technical Particulars of Lighting System and Equipment

Sr. No.	Description	Unit	Technical Particulars
12.19.1	**System Particular**		
(a)	**Voltage**		
	(i) 3 Phase, 4 wire 50 Hz system		
	• Rated	V	415
	• Maximum	V	476
	• One minute withstand voltage		2500 V AC.
	(ii) D.C. system		
	• Rated	V	110
(b)	System short-circuit level		
	(i) At 415 V, A.C.	kA (rms)	10
	(ii) At 110 V.D.C.	kA (D.C.)	6
(c)	Reference ambient temperature	^{0} C	45^0 C
12.19.2	**Distribution Board/Panels**		
(a)	Main, floor mounted distribution boards		
(i)	Main Lighting distribution board (A.C.)		

Sr. No.	Description	Unit	Technical Particulars
	• Make		As per Preferred Makes/ Manufacturers of Part-6, General requirement.
	• Type		Floor standing, sheet steel Enclosed
	• Degree of protection		IP 54
	• Busbar material		Copper
	• Busbar current rating	A	(*)
	• Short circuit current rating	kA	(*)
	• Cable entry		Top
	• Location		Indoor
(ii)	Emergency lighting panel (D.C.)		
	• Make		As per Preferred Makes/ Manufacturers of Part-6, General requirement.
	• Type		Wall mounting, sheet steel Enclosed
	• Degree of protection		IP 54
	• Busbar material		Copper
	• Busbar current rating	A	(*)
	• Short circuit current rating	kA	(*)
	• Cable entry		Top
	• Location		Indoor
(b)	Single phase DBs (SLDB), wall/structure mounting		
(i)	SLDB for indoor area		
	• Make		As per Preferred Makes/ Manufacturers of Part-6, General requirement.
	• Type		Wall mounting, sheet steel enclosed
	• Degree of Protection		IP 54
(ii)	SLDB for outdoor area		

Sr. No.	Description	Unit	Technical Particulars
	• Make		As per Preferred Makes/ Manufacturers of Part-6, General requirement.
	• Type		Wall mounting, sheet steel enclosed
	• Degree of Protection		IP 55
(c)	Paint Finish		
	(i) Colour shade:		Interior: Glossy white
			Exterior: Light grey semi glossy shade 631 of IS:5
12.19.3 (a)	**Street Light Poles and Flood Light Poles** Street Light Pole single arm		
(i)	Total Height:	m	7.5 for streetlight 3.0 for outdoor platform lighting
(ii)	Quantity:	Nos.	(*)
(b)	Floodlight Light Pole		
(i)	Total height:	mts.	9
(ii)	No. Of floodlights per pole	Nos.	(*)

12.20 Technical Particulars of Earthing and Lightning Protection System

Sr. No.	Description	Technical Particulars		
		Size	**Material**	**No. of Leads & Quantity**
12.20.1 (a)	**Main Earthing Grid** Buried in earth	(*)	MS/GS	Quantity as per requirement
(b)	Buried in floor slabs in buildings	(*)	GS	Quantity as per requirement
12.20.2	**Conductor Leads to Equipment** (Above ground)			Number of Leads As per relevant Standards, Quantity as per requirements
(a)	Transformers			
(i)	Transformer neutral to bottom of tank	(*)	GS	
(ii)	From bottom of tank to earth grid	(*)	GS	
(iii)	Transformer tanks and radiator bank	(*)	GS	
(b)	Diesel Generator Set			
(i)	DG Set neutral earthing	(*)	GS	
(ii)	DG Set body earthing	(*)	GS	
(c)	Fence posts and gates (Flex. braid)	(*)	GS	

Sr. No.	Description	Technical Particulars		
12.20.3	**11kV Metal Enclosed Switchboard, 415Vswitchgear/ MCC.**	(*)	GS	
(a)	Motors			
(i)	415V Motors above 10 kW	(*)	GS	
(ii)	415V Motors up to 10 kW	(*)	GS	
(iii)	Fractional horsepower motors	(*)	GS	
(b)	**Other Items**			
(i)	Capacitor panel, Battery charger panel, DC distribution board, Main lighting D.B, Control panels and sub-lighting distribution boards	(*)	GS	
(ii)	Handrails	(*)	GS	
(iii)	Cable trays	(*)	GS	
(iv)	Tanks	(*)	GS	
(v)	Junction boxes	(*)	GS wire	
(vi)	Lighting fixtures, receptacles, lighting conduits	(*)	GS wire	
(v)	Push button stations, limit switches	(*)	GS wire	
12.20.4	**Crane rail**	(*)	GS	
(a)	Street lighting, flood lighting poles and junctions' boxes	(*)	GS	
(b)	Metallic non-current carrying structures	(*)	GS	
12.20.5	**Lightning Conductors**			
(a)	Air Termination	(*)	GS	
(a)	Lightning protection downcomers for building	(*)	GS	
(b)	Lightning protection horizontal roof conductor for building	(*)	GS	
12.20.6	**Electrodes**	(*)	Heavy duty 40mm diameter (minimum) GI pipe (length as per IS 3043)	Quantity as per requirements
(a)	Pipe electrode	(*)		

12.21 Technical Particulars of Solar Panels

SL.NO.	DESCRIPTION	UNIT	TECHNICAL REQUIREMENT
12.21.1	**GENERAL**		

a	Application		Roof top & Tank Top
b	Cell type		Mono
c	Type of design		With frame / frameless
12.21.2	**ELECTRICAL DATA**		
a	Nominal minimum power @ STC	Wp	540 Wp
b	Module Efficiency	%	Min. 20
c	Operating temperature	^{0}C	+5 to +85
d	Maximum system voltage	V	1000 / 1500
e	Power tolerance	W	0 to (+)5Wp
f	PID free solar cells	YES/ NO	YES
12.21.3	**MODULE TERMINAL BOX**		
a	IP		68
b	Terminal cable		UV protected 4 sq.mm cable
c	Terminal connector		Solar PV Connector (MC4)
12.21.4	**BYPASS DIODE**		
a	Efficiency	%	> 99
b	Voltage drop	V	Not more than 0.7
c	Operating temperature	^{0}C	+5 to +85
12.21.5	Glass thickness	mm	3.2 ± 0.2
12.21.6	Anti-reflective coating required	YES/ NO	YES
12.21.7	Transmittance value	%	Min. 94 with one side coating Min. 95.5 with two side coating
12.21.8	Performance Warranty		25 years (Annual degradation curve shall be provided)

Note: Any requirement / features / provisions not specifically mentioned in the Specification but are necessary for trouble free and smooth operation of the Plant System shall be included.

(i) (*) – The numbers, ratings, sizes etc shall be worked out by the contractor during execution and to be approved by the Engineer.

(ii) Contractor shall notify the Employer for factory inspection and testing of equipment as defined in Clause 14.1.2, Materials, Plant & Equipment of Part 14, Volume -2 of the Bid document.

End of Part-12

PART 13

PARTICULAR INSTRUMENTATION AND CONTROL REQUIREMENT

Content

PART-13

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PART-13

Particular Requirements – Instrumentation, Control & Automation

13.1 Introduction

This part covers the particular requirements for the design, engineering, supply, Factory inspection and testing, Field testing & calibration, installation & commissioning of the instrumentation, Control and Automation (PLC-SCADA based Control System inclusive of wireless communication system) and associated plant and materials for successful operation.

13.2 General

This section outlines the particular requirements for the instrumentation, control & automation works. This section shall be referred in conjunction to the general requirements for instrumentation, control and automation works specified in Part-7 of this document. Unless specified in this section to the contrary, the system provided by the Contractor and workmanship shall comply with the General Chapters of these Requirements.

The scope of instrumentation, control and automation (ICA) works for Sewage Treatment Plant and ISPS's under this contract shall comprise of the design, manufacture, supply, programming and configuration, off site testing, delivery to site, installation and erection, testing, commissioning, setting to work and provision of documentation for a complete instrumentation, control and automation system including the interfaces required to provide monitoring and control for a safe and efficient operation of the plant locally as well as remote monitoring from the centralized SCADA Center to be established under contract package MIS-2 SCADA center at SHIMSHA Bhavan. The SCADA system shall be designed and configured to transmit complete WwTP and ISPS operational data (data transfer in bulk) to the centralized SCADA center MIS-2 as indicated above.

Note: The Contractor shall provide the following ICA equipment for each of the individual WwTP and ISPS under this contract.

The Contractor shall submit and obtain approval for all ICA equipment from the Employer's Representative before beginning the control system design and design submissions as per process requirement in line with Part-5. Refer approved vendor list for instruments and automation. Additionally, the Contractor shall note that the approved vendor list indicated in particular requirements is only for the product and not for executing agency to execute the work. The Contractor shall submit the credentials of the agency which shall be executing the work for review and approval as per qualification criteria indicated in the general requirements as per Part-7 before commencing any works. Only on the approval of the same, the Contractor shall commence works for instrumentation, control and automation works required under this contract.

The minimum scope of work for ICA at WwTP, ISPSs and LPSs under this contract shall include on a minimum, but not be limited to:

1) Design, supply, install, test and commission a dual redundant PLC based SCADA system including redundant communication System for WwTP. The system shall include at a minimum, but not limited to process controller including its central process units (CPUs in redundant hot standby configuration), redundant communication modules, Local/Remote IO's (Simplex), control networks, servers, Historian server and software, operator workstations, engineering workstation and printers;

2) All servers for SCADA, etc. shall be redundant (Refer control system architecture drawing in volume-iv)
3) Design, supply, install, test and commission field & analytical instrumentation for the Entire WwTP;
4) Design, supply, install, test and commission lab equipment & LIMS system for the Entire WwTP and the same shall be integrated in real time with the plant SCADA system.
5) Design, supply, install, test and commission chlorination system including its instrumentation and chlorination control units and its interface with WwTP PLC based SCADA system;
6) Design, supply, install, test and commission individual process systems, Vendor Package PLCs, RIO panels etc. including its instrumentation and control system units and its interface with main plant PLC system; No separate PLC system for monitoring and control of process system by the process vendor shall be accepted.
7) Design, supply, install, test and commission uninterrupted power supply system to supply the entire PLC based SCADA system including the Vendor Package PLC/ Remote I/O (RIO) systems and field and analytical instrumentation, wireless communication system, LIMS and lab equipment(as required);
8) Design, supply, test and commission standalone PLC system for ISPSs with required input/output modules, field instrumentation (Electromagnetic flowmeters at the common discharge of the pumps, pressure transmitters at common discharge of pumps and pressure gauges at individual and common discharge of pumps and level transmitter and GPRS communication modules) ,with 15" color panel HMI enclosed in with IP - 65 rated panels along with standalone UPS system with 60 min backup to control and monitor the pumping stations. The pumping station data shall be transmitted to the sewage treatment plant control system for complete control and monitoring with necessary security login and other safeguards as required.
9) The ISPS data shall be communicated in real time to the WwTP control system for monitoring at all times from the WwTP control system. The WwTP control system shall be designed and configured with each of the ISPS process mimics and all other ancillaries, electrical parameters, so that the ISPS can be monitored from the WwTP. In the event if the WwTP control system is not available/shutdown, the ISPS control system shall transmit the data to MIS-2 SCADA system. Once the WwTP control system is available, the ISPS control system shall transmit the data back to the WwTP control system for complete control and monitoring.
10) Design, supply, test and commission of field instruments for Lifting Pumping Stations (LPSs) with the following instruments as minimum and those are full bore electromagnetic flow meter & pressure transmitter on pumps common discharge line, Pressure Gauges on individual pump discharge and 4-point conductivity type level switches for pumps dry run protection.
11) Control room furniture include but not limited to industrial system consoles for placing servers, workstations and printer compartments, engineering workstation and printer compartment and ergonomic designed seating systems along with chairs and Almirahs. Refer vendor list for system console.
12) The Contractor shall be responsible for the design of each instrumentation and plant monitoring system, including the selection and design of appropriate transducers, transmitters, signal conditioning devices, indicators, alarm system programmable devices, communications, cable system etc. The Contractor shall take account in his design of all installation and environmental conditions prevailing at the site.
13) The Contractor shall ensure that complete WwTP plant operational data, all SCADA mimics inclusive of the Lab analyzed data is made available to the integration panel, which shall be installed under the centralized SCADA package for onward transmission to the centralized SCADA center-MIS-2 at Shimsha Bhavan.
14) All necessary required cabling-tray work, programming, software and hardware required to make the data available to the integration panel at all times, is part of the integral scope of work of the WwTP Contractor. The Contractor shall co-ordinate in full and conduct interoperability tests with the

centralized SCADA Contractor to ensure data is compatible with the data format which is required at the integration panel end.

CONTROL SYSTEM – DESIGN & CONSTRUCTION FOR WwTP AND ISPS

The PLCs and Input/output modules used for the Works shall be from the same manufacturer and series and shall, as far as practical, allow for the interchange of plug-in parts.

The PLCs and the central HMI shall be linked over dual line local area network (LAN) which shall be established on optic fiber cable with a single mode glass type.

A general arrangement of a typical control system is shown in the Drawing.

The control systems shall recover fully to a normal operational state on restoration of the power (either from the mains or the generator) after a power failure without manual intervention. (i. e. to remove doubt, this requirement refers to a real failure of power to the control system, such as would be experienced if the control system's UPSs were not present.

In all cases, facilities shall be provided to permit these automatic controls to be overridden and the systems to be manually controlled.

Local manual controls shall be located adjacent to the plant where required for day to day operation. All drives essential for the continuous operation of the plant shall be provided with a standby.

The process control system must be state-of-the-art in terms of structure and function as a process information and control system and its hardware and software must be future-oriented. The control system should be a modern system with an appealing user interface, open to the office and process world, with sophisticated and reliable functions, efficient to configure and scalable for simple and complex tasks.

The communication channels modules for the connection to the Programmable logical controllers via various communications media must be included in the scope of delivery of the control system, the same applies to drivers for simple types of coupling such as point-to-point via the MPI interface. In addition, it should be possible to establish the coupling to other devices and applications from various manufacturers via the standardized software interface OPC.

At a minimum, the SCADA hardware shall be based on the following:

- Main computer (SCADA server) Windows® Server (latest version)
- Operator stations - Windows Professional (latest version)
- Hardware and software from the PC sector can be directly used (e.g. LAN cards)
- Can be used as single-user or multi-user system with client/server structure

Scalable performance by selecting suitable hardware platforms.

Integral online parameterization option

A prerequisite is a comprehensive parameterization system that is integrated in the system, which allows the user to adapt the scope of functions and the functionality to any changed requirements without any programming expertise. The system must offer the option for carrying out these parameterization operations online. In practice, this means that the respective editor can run in a second window during

operation and the configuration engineer can make changes to his application without exiting process mode and also without affecting the background activities. In addition, it should be possible to make configuration changes on the client as well.

Hardware

The control system hardware shall consist of field controls which comprises on a minimum but not limited to:

PLC s;
Redundant power supplies;
local HMIs if any;
field cabling interfaces.
and central controls which comprises:
central SCADA and auxiliaries;
engineering station;
historian station;
CCTV System & Fire Alarm System inside Building;
Uninterruptible power supply & Battery Bank.

The site instrumentation shall also form an integral part of the control system.

The control panels shall provide separate areas for the PLC, internal power distribution, instrumentation, field cabling and for any surge (lightning) protection devices (SPDs). A separate instrumentation earth (a 'clean' earth) shall be established within the control panel. Instrumentation and control cable screens shall be connected to this earth.

The PLC / RIO Panels shall be double door conformal coating with sand blasting and having a minimum panel size of 900mm & Height not to exceed 2000mm, Gland plate-2mm, copper earth bus 25x6 mm, and panel painting is RAL 7035 (with interior Brilliant White Glassy Finish) with Ingress Protection of IP-54. The panel's front view shall be a lockable double door with transparent glass windows, allowing visibility to the panel-mounted HMI and controllers, etc. The Material of Construction for Panels shall be SS-316.

The central controls (SCADA) shall be located in the administration building(SCADA control room) for the monitoring of the treatment plant, which shall be at the central location of the Plant. The complete PLC-based SCADA system, inclusive of the Vendor Package PLC/RIO systems, shall be housed in an AC environment. Requirement of Air conditioning, humidity control, etc. shall be as per the Manufacturer's recommendations for all PLC system cabinets, marshalling, RIO Panels, as well as the Vendor Package PLC Systems. The size of the HMI for the vendor package control system shall be 10 inches as a minimum.

The control room shall be designed to have a complete view of the WwTP plant from the control room without any obstruction. Full scale glass windows shall be provided in the control room (from floor to ceiling), in addition to the false flooring and false ceiling. No cable shall be laid on the control room floor and the same shall be routed through ducts and conduits below the flooring. The Contractor shall note that no UPS system and related battery backup system shall be installed in the control room. There shall be separate room provided for the UPS system.

Power Supply

The control system shall be powered from the main Uninterruptible Power Supply System (UPS) located in the Panel Room of the Control Room, with a separate room for Batteries. In general power supply for vendor package PLCs/ RIO panel or any other ICA System present in the field shall be supplied from same UPS system.

These shall be sized to provide sufficient power to maintain the control system (inclusive of Sewage / Treated water quality monitoring instrumentation, vendor package instrumentation, LIMS system) systems functioning for a period of not less than 120 minutes on full load.

The UPS System shall be free standing provided with a bypass Transformer. The status of UPS shall be monitored and an alarm shall be raised via the control system if a fault occurs or the UPS battery supply is about to expire.

Voltages

The following control voltages shall be used:

Item	Voltage
1. within starter enclosures	240 V AC
2. instrumentation power supplies	240 V AC / 24 V DC
3. PLC inputs cards	24 V DC
4. PLC outputs	24 V DC

Control System Protection

1. **Short Circuit**
   All circuits shall be protected against short circuit by the provision of adequate numbers of fuses or miniature circuit breakers.
   For ease of maintenance and system security power supplies to each instrument loop and each PLC output shall be protected with an individual fuse (terminal type).

2. **Surge Protection**
   Surge protection devices (SPDs) shall be provided at the control panel end of all instrumentation and control cables which run for distances in excess of 50 m outside the confines of the building in which the CP is housed.

Duty / Standby Drives

The duty pump for each duty / standby pair shall be selected at the local control panel and the Plant HMI.

The control logic shall automatically start an ‘available’ standby in the event of the duty drive failing. The new duty drive shall take on the role of duty drive in all respects and shall continue to run as duty until manually reselected to standby or it fails.

Interlocking

Hard wired interlocking shall be provided for safety circuits such as:

- motor protection;
- run dry protection;
- emergency stop circuitry;
- rotation monitor.

In addition drives stopped as a result of the action of hardwired interlocks shall in addition have a fault signal conveyed to the drive in order that the PLC drive run output is removed.
Soft wired interlocking is provided by the PLC for process control and for safety trips when the signal is derived from a remote source (e.g. stopping of the treatment plant as a result of a high level in a downstream CCT).

Alarm Annunciation

Alarms shall be annunciated at three locations, at the drive starter, at the local Controller /RIO HMI as applicable and at the Local SCADA. A philosophy shall be adopted that all alarms associated with a drive shall be annunciated at the starter whilst a general alarm only for that drive shall be enunciated at the HMIs. Therefore, the operator observing a general alarm at an HMI shall have to go to the starter concerned to determine the exact cause of the alarm condition.

Communication Monitoring

The control system shall continuously monitor LAN communications and raise an alarm at the central SCADA if communications should fail between the SCADA and a controlling PLC/Vendor PLC / RIO or between PLCs if inter-PLC communication is being used. A separate SCADA screen (mimic) showing the real time status of PLC's, I/O modules, LAN communication ,RIO status, etc. is to be incorporated.

13.3 Interface to the ISPS Control System & Central SCADA Stations at MIS-2 @ Shimsha Bhavan

(a) General

Data from the Intermediate Sewage Pumping Stations (ISPSs) is required to be passed to the respective Sewage Treatment Plant for use in its control and monitoring and for onward transmission of WwTP data to enable remote monitoring from the centralized SCADA Center to be established under contract package MIS-2 SCADA center at SHIMSHA Bhavan.

(b) The Interface

The interface shall be housed in a separate IP-65 rated control panel provided by the Contractor. The Contractor shall provide facilities to output from the Pumping Station control system via this control panel the signals to be sent and to accept the signals provided. The Contractor shall provide the redundant GPRS wireless communication from the ISPS control system to the WwTP control system and contract package BWSSB MIS-2 SCADA center at Shimsha Bhavan.

All required data from the WwTP control systems including ISPS data shall be communicated to the Central SCADA at Shimsha Bhavan via wireless GPRS redundant network. Communication between the interface control panel of the Central SCADA System and the WwTP control system shall be carried out by the WwTP Contractor. The Contractor shall provide termination details to permit these connections to be carried out. The Contractor shall co-ordinate in full with other Contractors to interface with Central SCADA system so that the entire SCADA system for WwTP system can be provided completely.

Interoperability Test & Integration co-ordination:
The WwTP/ISPS package Contractor shall conduct a interoperability test to confirm & demonstrate that the local control system data can be read & written by the contract package BWSSB MIS-2 SCADA center at Shimsha Bhavan, using appropriate OPC server & client software via the interface panel and local PLC/SCADA. The test shall be carried out in presence & co-ordination with the centralized SCADA control centre Contractor/system integrator.

It is required that the WwTP/ISPS Package Contractor maps his local I/O's for integration in the same format as required at centralized SCADA control centre.

The WwTP/ISPS Package Contractor shall coordinate fully with the centralized SCADA control centre Contractor for integration tests. The WwTP/ISPS Package Contractor shall be fully responsible for data to be made available at the interface panel end at all times, which is connected the integration system.

(c) Data to be provided by the WwTP & ISPS Control System to MIS-2 SCADA

The WwTP Contractor shall provide complete SCADA screen dumps to enable complete WwTP and ISPS monitoring and control (as required) from the Centralized SCADA centers.

The following signals are to transmitted by the Contractor to the interface at a minimum, but not limited to:

- Sewage water flow (Ml/day);
- Treated Sewage parameters to confirm to contract conditions;
- final turbidity (NTU);
- final chlorine residual (mg/l);
- power consumed / day (kWh);
- chemical consumption;
- LIMS data;
- total flow / day (Ml);
- power outage hours / day (h);
- power outage at treatment works;
- Real time online inlet and effluent monitoring system data;
- Total plant screen dumps
- Alarms
- Asset information with tags
- Reports
- Local Historian data
- Status of fire alarm and suppression system

The minimum scope of work for ICA at WwTP shall include but not be limited to:

1) Design, supply, install, test and commission a dual redundant PLC based SCADA system for WwTP. The system shall include at a minimum, but not limited to process controller including its central process units (CPUs in redundant configuration), redundant communication modules, RIO's as required, Simplex input-output (I/O) modules(Hot swappable), redundant I/'O's for critical inputs (around 15% of total I/O considered), control networks, servers, Historian server and software, operator workstations, engineering workstation and printers;

2) All servers for SCADA, etc. shall be redundant (Refer control system architecture drawing in Volum-iv)

3) Design, supply, install, test and commission field & analytical instrumentation for the Entire WwTP;

4) Design, supply, install, test and commission chlorination system including its instrumentation and chlorination control units and its interface with WwTP PLC based SCADA system;

5) Design, supply, install, test and commission centrifuge system including its instrumentation and control units and its interface with WwTP PLC based SCADA system

6) Design, supply, install, test and commission Disc Filter system including its instrumentation and control units and its interface with WwTP PLC based SCADA system

7) Design, supply, install, test and commission Laboratory Information management system (LIMS) including all lab equipment and its interface with WwTP PLC based SCADA system for monitoring and record of all lab equipment as per prescribed local and international standards.

8) Design, supply, install, test and implementation of Interface to the ISPS PLC based Control System with WwTP & MIS-2 SCADA System at Shimsha Bhavan.

9) Design, Supply, install, test and commission a dedicated RIO panel with Panel mounted HMI for continuous control & monitoring of Terminal Sewerage Pumping Station (TSPS) from the plant wide Hot Standby PLC / SCADA system.

10) Design, supply, install, test and commission individual process systems Package PLCs/ Local Controllers / RIO panels including its instrumentation and control system units and its interface with main plant PLC system; Any Vendor package process systems with Package Control System shall communicate with the main plant PLC for monitoring and control .

11) Design, supply, install, test and commission uninterrupted power supply system with 120 mins backup on full load, to supply the entire PLC based SCADA system including the Package PLCs, Equipment's Local Control Systems, Remote I/O (RIO) systems and field and analytical instrumentation and associated instrumentation, communication interface consisting of RTU and GPRS modems.

12) Design, supply, install, test and commission CCTV system including its interface with main plant SCADA system; The Contractor shall install the CCTV cameras at all process locations. During construction ,the CCTV system shall be installed at all process locations/construction points and the CCTV feed shall be used to monitor the project progress from any BWSSB office in real time. Contractor shall ensure that the CCTV feed is web based and can be accessed through standard web browsers. High speed broadband internet connection shall be utilized on-site to relay the CCTV feeds as required for monitoring from any BWSSB office.

13) Control room furniture include but not limited to industrial grade system consoles for placing servers, workstations, engineering workstation and Laptop with printer compartment and ergonomic designed seating systems, Almirah etc. Refer vendor list for system console

14) The Contractor shall be responsible for the design of each instrumentation and plant monitoring system, including the selection and design of appropriate transducers, transmitters, signal conditioning devices, indicators, alarm system programmable devices, communications, cable system etc. The

Contractor shall take account in his design of all installation and environmental conditions prevailing at the site.

15) The Contractor shall ensure that complete WwTP plant operational data, all SCADA mimics inclusive of the Lab analysed data is made available to the integration panel.

16) All necessary required cabling, programming, software and hardware required to make the data available to the integration panel at all times, is part of the integral scope of work of the WwTP Contractor. The Contractor shall co-ordinate in full and conduct interoperability tests with the centralized SCADA MIS-2 Contractor to ensure data is compatible with the data format which is required at the integration panel end.

13.4 System Completeness

This section of specifications defines the particular requirements of instrumentation, control & automation works to be installed at WwTP and ISPS.

Irrespective of the detailed specifications of the respective items detailed in the various chapters of the tender specification, the Contractor shall be required to provide all the equipment, accessories, cabling, earthing, providing necessary transducers/sensors, system hardware/software, programming logic, interlocks, cabinets, panels etc. to achieve the functional requirements described in the Bid Document. The System completeness shall be the Contractor's responsibility.

Note: In FAT, all the field instruments shall be tested for functionality as per contract requirements at the manufacturers work location where the equipment is manufactured. Quality assurance plan (QAP) shall be submitted along with the datasheets for review and approval before any inspections call is initiated.

13.5 Field Instrumentation and Control

Each field instrument shall be operable in local mode and have display functions in SCADA. The Contractor shall be responsible for providing the appropriate signals at the locations required to provide the specified control and monitoring functions.

The Contractor shall ensure that field measuring systems shall respond quickly to any changes of the measured process variables.

All field instruments shall, as far as practicable, be mounted in a location that shall be free of vibration and shall be powered from the instrument control system.

24V DC power wiring for field instruments shall be individually fused and provided with a means of disconnecting the power without disturbing terminated wiring (e.g. knife-switch-type terminal blocks). Visual indication of a blown fuse condition shall be provided.

All field instrument components shall be of a proven and reliable design and shall have a high degree of uniformity and shall, wherever possible, be interchangeable. The design shall facilitate easy maintenance and repair, taking into account the availability of access routes through plant and structures generally.

Field Instruments shall perform sensing, indicating, transmitting and controlling. The devices shall generally interface with the SCADA, either directly or indirectly. The materials of those parts of the field

instruments, including piping material, which are exposed to the measured media shall be compatible with the conditions of the respective media and of the ambient fluid and atmospheric conditions.

All field instruments shall be mounted within enclosures that are corrosion proof, dust proof and waterproof to provide a minimum protection specified elsewhere in this Specification. The enclosure shall be rated to minimum IP 65. The enclosure design shall be submitted along with the instrument datasheet for review and approval before proceeding with any design work.

All field instruments, including the components, shall be tropicalized and designed for the ambient conditions detailed elsewhere in this Specification. Lighting protection barriers shall be used for protecting transmitters and receiving instruments from the surge voltage due to lighting strike. Lighting protection barriers shall be supplied at both receiving and sending ends for all signals from outside building and those installed between the buildings.

13.6 Instrumentation Design Criteria

The design criteria to be applied to instrumentation systems shall be as follows:

1) all instruments shall be suitable for continuous operation;
2) all transmitting instruments shall have a 4 - 20 mA HART linear output;
3) all digital outputs shall be volt free;
4) all instruments shall be designed for the ambient conditions of temperature and humidity;
5) all wetted parts of instruments sensors shall be non-corrosive and suitable for use with sewage;
6) all instrumentation systems for use out of doors shall be protected to IP 65;
7) all analogue displays shall be of the digital type with no moving parts utilising back lit liquid crystal diode LED technology;
8) instrumentation shall utilise solid state electronic technology and avoid the use where practical of any moving parts;
9) minimum maintenance requirement;
10) Instrumentation shall resume operation automatically on the application of power following a power failure.
11) All analytical instruments shall be single channel and have individual analyzer units.

Instrumentation systems shall be provided as detailed in the Employer's Requirements and as necessary for the efficient and safe operation of the treatment plant

The Contractor shall provide systems to measure any other parameter required for the efficient and safe operation of the treatment plant.

Instrumentation sensors shall be suitable for the environment in which they are expected to work. Sensors located in hazardous (flammable) or potentially hazardous atmospheres shall be certified for use in these areas.

Instrumentation shall be selected and installed in accordance with the manufacturer's instructions. Wherever practical components of similar systems shall be interchangeable, i.e., open channel flume flow measuring systems and open sump or tank level measurement and pump control systems shall incorporate identical sensors and converter units. Instrumentation converter units shall where practical be located in the associated MCC common control panel well away from any injurious effects of the process.

13.7 Flow Measurement and Control

The Contractor shall use electromagnetic flow meters, for all closed pipe liquid flow measurement as the standard flow meters under this contract. Each flow meter shall be installed in the pipeline within a suitable access chamber. The access chamber shall be designed to provide adequate space for personnel access to the chamber and around the flow meter for maintenance. The flow meter system shall provide flow rate and totalized flow indication.

The pressure rating of the flow meter and flanges shall be equal to or greater than that of the pipeline within which it is installed. The preferred location for the flow meter converter/transmitter units is within a building. Where this is not possible, then the converter shall be installed in a suitable above ground enclosure providing the converter with suitable mechanical and environmental protection.

The flow signal converters/transmitters shall provide 4-20mA output linearly proportional to the rate of flow and shall provide a pulse output for flow totalizing. The flow meter electronic supervisory unit shall display the following on a minimum:

- Flow rate;
- Flow total-totalizer;
- High flow rate alarm;
- Low flow rate alarm.

Signals for the items above shall form inputs to the PLC and SCADA and be utilized within Operator displays. The integrator used for the second item above shall have at least six digits.

Each flow meter shall be provided with downstream and upstream isolation valve including the washout facility.

The sewage water inlet flow shall be measured using an open channel flume type system located in the inlet channel. The head loss across the flume shall be monitored using ultrasonic fully sealed detectors. A local readout of flow in Ml/day shall be provided.

Electromagnetic Flow Meter

Electromagnetic Flow Meter: Supply, Installation, Testing & Commissioning of Full Bore Electro-Magnetic Flow Meters compatible for Raw Sewerage Pumping Stations
Full bore bi-directional electromagnetic flow meters shall be designed, manufactured and calibrated as per ISO/IEC 17025 standard. Meters shall also have actual Flow rate & Totalized value. The accuracy shall be +/- 0.5% of reading.

The sensors shall be as per ISO standard lengths (ISO 13359), so that interchangeability can be carried out for the applicable flow meter sizes. The sensor shall also have built in grounding and empty pipe detection electrodes of SS316 for detecting partial flow condition & efficient operation purposes. The liner material shall be Polyurethane (PU) / PTFE/ Hard Rubber (NBR) as per sewage medium application. The sensor & transmitter shall be capable of working in tropical environment.

The sensors shall be rated IP68. The transmitter shall be rated IP67 in line with local operating conditions. Installations shall be made with cables and /or conduits that guarantee the integrity of the system under all operational conditions. The transmitter/ converter shall be wall-mounted type with a 2 line display for the indication of Actual Flow rate & Totalized value. A glass window within the protection enclosure with optical switches shall be provided for local reading purposes.

The enclosure material shall be non-corrosive and of die cast material. Magnetic flow meters should be supplied with built in software feature to analyze and continuously monitor the health of the sensor, display errors in text format. Transmitter should be capable of performing the verification program on demand or on request without taking meter off the line.

The transmitter shall be capable of being fully programmable. It shall have a set-up menu so that all relevant parameters may be user-set from the self-prompting driven menu.

The transmitter shall have totalizer units and shall have one (1) scalable pulse output & one (1) current i.e.4-20mA HART output. The current output shall be galvanically isolated. It shall be fitted with switched mode power supply capability 0-250V or 24 DC and 45-65Hz to cope with power transients without damage. The Totalizer value shall be protected by EEPROM during power outage, and utilizes an overflow counter.

The transmitter shall be having facility of indicating flow measurement. It shall be possible to separate the sensor and transmitters up to 200 meters without the need for signal boosters or amplifiers
Detailed technical specification of Full bore electromagnetic flow meter is as below

General		
1	Process Medium (Suitable for)	Sewage / Effluent Water
2	Op Temperature	0 to 50 Deg C Max
3	Op Pressure	Max 6 Bar g
4	Measurement	Instantaneous flow Rate, Totalized Flow
Flow Sensor		
5	Type	In-Line Full Bore Electromagnetic flow meter.
6	Power supply type	Mains operated
7	Sizes (mm) /Qty	As per flow sizing calculations (in line with line velocity requirement to meet flow meter accuracy)
8	Sensor Type	Pulsed DC
9	Process Connection	Flanged type
10	Weather Protection Class	IP68 as per /IEC 60947
11	Full Scale Velocity	0.5 to 12 m/s, vendor to provide the detailed sizing calculations based on the process details.
12	Electrodes	SS 316 L, Total 2 Electrodes system. Measuring electrodes – 2 Nos.
13	Coil Housing	Powder-coated die-cast aluminium Anti corrosive grade with IP 68 protection class with minimum 20 meter cable for remote mount transmitter connection
14	Flanges	Carbon Steel PN 10 as per EN 1092-1
15	Flow sensor Grounding	Grounding rings shall also be acceptable
16	Flow Tube material	SS304

17	Flow Tube Liner	Polyurethane / PTFE / Hard Rubber (NBR) [Suitable for sewage application as per Original Equipment Manufacturer recommendation]
Flow Transmitter Unit		
1	Type	Microprocessor based with facility to configure the range
2	Type of Display	2 -Line LCD display with operation keys (touch control)
3	Transmitter Type	Remote Wall Mounted with 5 cable glands, integrated fixing points for wall mounting, with sensor interface
4	Units for Display	Flow Rate M3/Hr, Totalized Flow M3
5	Input	From Flow Tube
6	Accuracy	+/- 0.5 % of Measured Value
7	Operation	Via local display, Via HART handheld terminal
8	Output proportional to Flow rate	Current output (4–20 mA HART); RS 485 MODBUS, pulse/frequency/switch output (2); status input
9	Power supply	100 - 230 VAC, 50 Hz
10	Self-diagnostic feature	Following minimum diagnostic features shall be provided Empty pipe detection, system diagnostic features
11	Transmitter enclosure material	Non-corrosive, Die Cast Aluminium
12	Communication	RS 485 MODBUS Suitable for Wired communication with control system and HART based integrated and service interface
13	Memory	100% secure data storage
14	Weather Protection Class	IP 67 (NEMA 4X) for flow transmitter

Note-1: The flow meter manufacturer/supplier shall have full ISO 9000 series accreditation and fully traceable calibration methods. The suppliers shall also have a testing facility in India so that methodology and procedures can be verified. Each meter shall be wet calibrated with 5 point calibration to verify performance in accordance with the specification & submit report for the same. The testing facility shall be duly accredited in accordance with ISO/IEC 17025 standards.

In the event if the meter manufacturer does not have a testing facility in India, the flow meter shall be tested & inspected before shipping at the Manufacturers factory works, where the meter has been manufactured.

Note-2: The flow meter manufacturer shall have local offices in India and full service capability in Bengaluru. Full contact details for key personnel, shall be furnished on request. The supplier shall provide evidence of at least five years involvement in the manufacturing of meters worldwide.

Note-3: The flow meter manufacturer shall provide full data on each meter required, including optimizing and sizing programs calculation sheet.

13.8 Thermal mass flow meter for gas (air) for continuous measurement of flow

Thermal mass flow meter shall be utilized as mass air flow meters to measure air flow or bio gas flow as applicable under this contract.
The sensor shall not cause any pressure loss and no pressure and temperature compensation shall be required. The meter shall be able to measure Mass flow, temperature, volume flow and energy flow

The degree of protection for the sensor and transmitter shall be rated to IP67.

Measuring Principle	Thermal dispersion principle
Sensor features	Shall offer high accuracy and repeatability for a wide range of utility and process gases.
Measuring Task	Flow (Mass), Gas temperature, Gas heat flow
Accuracy	+/- 1.5%
Sensor, Insertion tube material	Stainless steel
Compression fitting seal	PEEK
Material process connection	Stainless steel
Transmitter housing material, Coating	Powder coated die-cast aluminium, powder coating
Degree of protection	IP67 (NEMA 4X) for transmitter and sensor
Max. measured error	Gas: 1.5% or (10 to 100% o.f.s.)
Display/Operation	LCD/LED: back-lit, Configuration via local display and operating tools shall be possible
Outputs	4-20mA HART (active/passive selectable), pulse, frequency, status
Hazardous area approvals	Required (As applicable)

Note-1: The flow meter manufacturer/supplier shall have full ISO 9000 series accreditation and fully traceable calibration methods. The suppliers shall also have a testing facility in India so that methodology and procedures can be verified. Each meter shall be wet calibrated with at sufficient flow rates to verify performance in accordance with the specification & submit report for the same. The testing facility shall be duly accredited in accordance with ISO/IEC 17025 standards.

In the event if the meter manufacturer does not have a testing facility in India, the flow meter shall be tested & inspected before shipping at the Manufacturers factory works, where the meter has been manufactured.

Note-2: The flow meter manufacturer shall have local offices in India and full service capability in Bengaluru. Full contact details for key personnel, shall be furnished on request. The supplier shall provide evidence of at least five years involvement in the manufacturing of meters worldwide.

Note-3: The flow meter manufacturer shall provide full data on each meter required, including optimizing and sizing programs calculation sheet.

13.9 Flow Switches (Load Monitor)

1) The load (kW) monitor shall be suitable for mounting within the appropriate motor starter section of the motor control centre. The device shall be used primarily to detect low or no flow situations. However, it may be utilised to detect overload situations where appropriate.
2) In low or no flow mode the load monitor shall monitor drive power. If the measurement of the power falls below an adjustable set value (P-min) an output-relay shall be de-energised to cause the pump set to stop.
3) The monitor shall incorporate the following features:

a) DIN-rail mounting
b) adjustable start-up delay time
c) adjustable reaction time
d) three monitoring measuring ranges, selected externally on unit
e) normally energised, or de-energised mode
f) output signal may be latched, or automatically reset
g) LED indicators for mains on indication and status
h) Relay output; 1 No. changeover contact.

4) The monitor performance specification shall be as follows:

a) Reaction time - 3 to 30 seconds adjustable
b) Start-up delay time - 0.15 for 20 seconds adjustable
c) Switching capability - 1 A (24 V), 0.1-8 A 250 V ac, 1 100 VA)
d) Maximum switching current - 10 A

13.10 Rotameter

Type	On-line up to 2". By-pass above 2"
Metering tube	Borosilicate glass
Float	AISI 316-SS unless the process fluid demands some other material.
Body MOC	AISI 316-SS
Scale	Graduated- Engraved black on white background.
Process connection	Flanged
Accuracy	± 2% of full scale detection or better for on-line type and ±4% of full-scale detection or better for by-pass Type.
Nameplate	Tag number, service engraved in stainless steel tag plate
Accessories	Slip-on orifice plate of 316-SS and taps of Stainless Steel as per application requirements. Applicable

SS Isolation valves and SS Range Orifice – for Bypass type rotameters.

13.11 Level Measurement and Control

The following section describes the minimum technical specifications for level measurement and control under this contract.

Owing to the nature of sewage and sewage sludges, non-contact methods of level measurement are preferred. Where foaming problems are identified as a local concern, the level measurement by level transducer shall be considered. Float switches are reserved as backup to the level indicating transmitters.

Sensing heads shall be mounted on 316 stainless steel brackets and positioned to ensure an unhindered beam path and ease of access for maintenance.

13.12 Radar Type Level transmitter:

	Transmitter	
1	Type	Non-Contact Radar Type Level Transmitter
2	Principle	FMCW (Frequency Modulated Continuous Wave)
3	Output	4-20 mA HART current
4	Housing	Die Cast Aluminium
5	Electromagnetic compatibility	Interference Immunity to EN 61326, Annex A (Industrial) and NAMUR Recommendation NE 21 (EMC)
6	Ingress Protection	IP 67
7	Accuracy	+/- 3 mm
8	Area Classification	Non-Hazardous. Hazardous
9	Display	4 line LCD display. Service: Display of Envelope curve.
10	Configuration	Using Keypad on display
	Sensor	
11	Range	0 to 5m and 0 -15m depending on Tank size [As per Process requirement]
12	Temperature range	-40°C ... +80°C
13	Max Pressure	3 bar abs
14	Materials	Sensor: PVDF Seal: EPDM
15	Antenna seal	FKM Viton
16	Process connection	Threaded or universal flange dependent on model selection
17	Degree of protection	IP68
18	Frequency	80GHz

13.13 Float Switches

1) Level switches of the buoyancy type shall consist of a non-mercury switch with changeover action enclosed in a non-corrodible material. A balance weight shall also be incorporated in the switch to counteract the buoyancy effect of the specific gravity of the particular fluid. The connecting cable shall be factory sealed to the switch. The switches shall be installed in a stiller tube in the wells.
2) Level switches shall be installed with a minimum of 3 m of spare connecting cable neatly coiled at a supporting bracket. The connecting cable fixing shall facilitate any alteration in operating level within the limit of the spare cable.
3) The level switches shall act as backup to the level transmitter in the control interlock sequence.

13.14 Sludge Blanket Level Monitor

1) The device shall be used to detect the pressure of sludge or a sludge blanket level.
2) The device shall operate on ultrasonic principles employing two sensors acting as transmitter and receiver. The absorption of the beam by the presence of a sludge or slurry shall initiate a switching action which may be used for control purposes.
3) The device shall be unaffected by vibration, temperature or viscosity of medium being detected.
4) The ultrasonic sensor frequency shall be selected with regard to the medium in which it is to be used.
5) For sludge blanket level detection the sensor shall be suspended/fixed in the tank concerned at the required level. The sensor shall be secured to a corrosion resistant pipe in order to 'steady' the sensor. It shall be possible to adjust the level of the sensor and to remove it easily if required for checking and cleaning.
6) Pipe mounted sludge detectors shall be mounted on opposite sides of a pipe section with the sensor faces flush with the inner pipe surface, in order to promote self-cleaning of the sensor faces by the flow of sludge. The pipe section shall be lined with an epoxy lining or other suitable chemical resistant lining material in order to prevent the build-up of grease in the region of the sensors.
7) The sensors shall operate in conjunction with a converter. The converter shall be provided with the following features:

a) LED sensor status indicators
b) DPCO relay output
c) Internally selectable time delays (typically 0.5 to 30 seconds).

8) The converter shall be provided with sensitivity control typically providing a range of 1: 20.

13.15 Level Gauge (Float & Tape)

1)	Type	:	Float and Tape
2)	Float & Tape MOC	:	AISI 316
3)	Pulley Housing	:	Aluminum
4)	Guide wire	:	SS 316 Stainless steel
5)	Accuracy	:	+/- 2 mm
6)	Indication	:	On circular or vertical dial
7)	Rating	:	Twice the design pressure

13.16 Sight Glass

1)	Type	:	Flap-type
2)	End connection	:	Screwed / Flanged
3)	Material		
	a) Body	:	SS-304
	b) Cover Plate	:	SS-304
	c) Indicator	:	SS-316
4)	Sight Glass	:	Toughened Borosilicate
5)	Gasket	:	Neoprene
6)	Bolts & Nut	:	High tensile steel
7)	Hydraulic Test Pressure	:	1.5 times maximum working pressure
8)	Accessories	:	As required

13.17 Pressure Instrumentation

Pressure Gauges & Pressure Switches:

1) Pressure gauges shall comply with BS EN 837- Parts 1, 2 and 3. Pressure Gauges, Switches & Indicating Transmitters shall have over range protection up to 1.5 times the maximum anticipated line pressure.
2) Internal parts shall be of stainless steel, bronze or other corrosion resistant material.
3) All Pressure Gauges, Switches shall be supplied complete with isolating valves and calibration points to enable calibration or removal without loss of fluid.
4) Where compensation of more than 2% of the instrument span is needed for the difference in level between the instrument and the tapping point, the reading shall be suitably adjusted and the amount of compensation marked upon the dial.
5) Pressure and differential pressure switches shall have contacts with separate 'cut in' and 'cut out' pressure values.
6) The nominal pressure values at which pressure switches operate shall be fully adjustable over the whole range of the instrument and the set value(s) shall be clearly indicated by means of a scale and pointer.
7) Pressure monitoring shall be by a sensor suitable for the medium and pressure/level range.
8) The sensor shall be selected to provide adequate sensitivity over the working range and be capable of sustaining a 400% overpressure without damage. The sensor shall be suitable for either free wire suspension in the medium or fitted remotely and provided with threaded sockets to permit connection of pressure pipe work.
9) A transmitter shall be provided either integral with the transducer or separately mounted and converting the signals received from the transducer to a 4 to 20 mA signal proportional to the range specified.
10) The transmitter shall have provision for span and zero adjustment.

Pressure Transmitters:

Pressure measuring system shall consist of pressure transmitter and digital pressure indicator and any other items required to complete the pressure measuring system. Pressure transmitter shall be rugged in construction and shall be suitable for continuous operation. Pressure transmitters shall be designed for operation over 130% of full range. It should have EEPROM for storing of history data.
Pressure transmitter shall be suitable for field mounting. They shall provide 4-20 mA Current output proportional to pressure. Transmitter output shall be isolated and shall be suitable for transmitting over long distance. Pressure transmitters shall have high degree of weatherproof protection as specified in technical particular. Pressure transmitters shall have LCD display to indicate pressure.

The Contractor shall mark the exact location of pressure measuring point on the pipe line. The Contractor shall provide all the hardware items including manifolds, nuts, bolts, pipes, valves, gaskets etc. required for the work.

Sr. No.	**Detailed specifications for Pressure Transmitters**	
1	Pressure Range	0 to 10 /20/50/ 100 Kg/cm2 g [As per Process Requirement]
2	Process Temperature range	-20 to +125 deg.C.
3	Output Signal	4 to 20 mA with superimposed digital communication protocol HART 6.0, 2-wire
4	Signal range –	4 to 20 mA HART

Sr. No.	**Detailed specifications for Pressure Transmitters**	
		3.8 to 20.5 mA
5	Signal on alarm	As per NAMUR NE 43 • 4 to 20 mA HART
6	Resolution	Current output: 1 micro Amp
7	Response time	<250 ms
8	Damping	required
9	Supply voltage	11.5 to 45 V DC
10	Reference accuracy	± 0.1%
11	Housing	Die Cast Alu. Housing
12	Diaphragm Material	Ceramic
13	Long Term Stability	± 0.25% URL/year
14	Turn Down	10 : 1

Differential Pressure Transmitter

1	Working Principle	Smart
2	Type	2-Wire
3	Output signal	Superimposed field bus over 4-20 mA DC.
4	Signal Processing Unit	Silicon solid-state electronic circuitry
5	Measuring element	Capsule/ Diaphragm
6	Element material	AISI-316 (Stainless Steel) or better
7	Static Pressure/ Overload Pressure	Maximum line (or static) pressure on either side without permanent deformation or loss of accuracy
8	Turn-down ratio	100 : 1 minimum
9	Span and Zero	Locally adjustable, non-interacting
10	Enclosure class	IP-65
11	Zero suppression / Elevation	At least 100% of Span
12	Output Indicator	LCD type
13	Performance:-	
	• Accuracy	±0.1 % of span or better
	• Repeatability	± 0.05 % of span or better
	• Response time	100 mSec or better
14	Sealing / Isolation	Extended diaphragm with 5 meters SS armoured capillary for viscous fluid applications.
15	Accessories	a) Universal mounting bracket suitable for 2” pipe mounting.

		b) High tensile carbon steel U-bolts.
		c) Companion flange with nuts, bolts and gaskets.
		d) Hand held configurator kit for calibration of Smart Transmitter.
		e) ½" NPT cable gland
		f) ½" NPT generally 5-valve stainless steel manifold, constructed from SS316 bar stock.

13.18 Temperature Instrumentation

Unless otherwise specified, platinum resistance elements shall be used for measuring spans of up to 200°C and chromel-alumel thermocouples for spans exceeding 200°C.

The accuracy for temperature meters shall be ±0.03% of span. Configuration data shall be stored in the EEPROM memory.

In critical and important application, the temperature sensors shall be of a dual type arrangement for easy replacement. Each temperature sensor, unless otherwise specified, shall have a stainless steel thermo well, or pocket-and-extension assembly, non-corrodible metal sheath and waterproof terminal head. Pockets for steam, oil and pressurized-water lines shall be welded; pockets for other duties shall be screwed. The sensor assembly shall be designed to permit removal of the temperature element without twisting the leads.

Platinum resistance thermometers shall comply with BS 1041 and BS EN 60751 or equivalent Indian Standards on the approval of the Employer Representative. Sensors shall have a resistance of 100 ohms at 0°C and shall conform to the European standard curve (DIN 43720), where Alpha = 0.00385. Each element shall be artificially aged during manufacture. Terminal heads and amplifiers shall be designed for four-wire connections between head and amplifier. Platinum resistance elements shall be spring-loaded and fully encapsulated in ceramic material and the elements and high-temperature-resistant lead wires shall be hermetically sealed. The associated resistance-to-current converters shall have zero and span adjustments and input-output circuit isolation.

Thermocouples shall be of the mineral-insulated type and unless otherwise specified shall be of the chromel-alumel (nickel-chromium vs nickel-aluminum) type and shall comply with BS 1041 and BS EN 60584-1.

Thermocouple junctions shall be welded. Ceramic-insulation material may be used for base-metal thermocouples but low-silicon insulation material shall be used for noble-metal thermocouples. Thermocouple systems shall have thermoelectric ice point reference chambers or receivers or amplifiers with automatic cold junction compensation.

Thermocouple receivers and amplifiers shall also have zero and span adjustment, common and series mode interference rejection circuits, radio-frequency filters, input-output circuit isolation and thermocouple break feature whereby the output is driven to zero or full-scale, as stipulated by the Employer Representative, when the receiver or amplifier input circuit is broken.

Thermocouple elements shall be electrically isolated from their sheaths but each terminal head shall have facilities for earthing the thermocouple and for terminating the screen of the extension or compensation cable.
Amplifier chassis shall have facilities both for being earthed to the instrument case via a capacitor and for being electrically isolated from the instrument case.

Temperature transmitters shall be of rugged construction microprocessor based instruments. They shall provide simultaneous digital and analogue outputs and the 4mA to 20mA dc output shall be linear with temperature.

13.19 Temperature Switches

Temperature switches shall have contacts with differing 'cut-in' and 'cut-out' values. Their nominal operating points shall be fully adjustable over the whole range of the instrument and the set-value shall be clearly indicated by a dial and pointer.

Note: - RTD's of Winding and Bearing Temperatures of Pumps / Motors shall be monitored through Temperature Scanner Indicators.

13.20 Strain-gauge Load Cell Weight Indicator and Transmitters

Weight Indicator Transmitter shall comprise of Compression Type Strain Gauge Load Cells along with Transmitter and Indicator for measurement of Sludge Hopper Weight Applications in Sewage Treatment Plant. Strain Gauges shall be mounted on the top and bottom to measure Tension and compression forces.

Measuring Range	As per Process Requirement
Temperature Range	-30oc to + 80oc
Accuracy	+/- 0.5 % of Measured Value
Supply Voltage	24 V DC
Output	4-20mA
Indicator Display	Required

13.21 Online Analytical Instrumentation

Online Analytical Instrumentation shall be used to provide continuous monitoring of effluent quality to permit the performance of the sewage treatment plant to be assessed on a continuous basis and to provide early warning of plant malfunction or failure. Where appropriate, Online analytical instrumentation shall also be used to monitor functions not related to effluent quality as per Part-5.

The monitors and their associated sensors or cells shall be selected as appropriate to the particular application.

In all cases, the location and housing of the monitor shall take into account the provision of a representative sample to the monitor sensor, the pre-conditioning if any, required prior to the sample's analysis, operator requirements for access, maintenance, calibration, repair and replacement of the monitor or its sensors.

All online analytical instruments shall be single channel and shall have individual analyzer units only.

Note:

Contractor will include the manufacturer's services to perform start-up on instrument to include basic operational training and certification of performance of the instrument.

Contractor will include a manufacturer's Service Agreement that covers all the manufacturer's recommended preventative maintenance, regularly scheduled calibration and any necessary repairs beginning from the time of equipment startup through to SAT acceptance and operation & maintenance period.

The above are to be performed by manufacturer's factory-trained service personnel only. Field service and factory repair by personnel not employed by the manufacturer is not allowed. Manufacturer's service parts and reagents shall be used. Third-party parts and reagents shall not be accepted and used.

I. Online Turbidity Measurement:

Online sensor shall be based on Nephelometric measuring principle with 90deg scattering light method as per ISO 7027.The sensor shall be of plug and play type with digital communication .The sensor shall be with IP68 rating suitable for measuring range 0 to 9999 FNU /NTU with accuracy of <2% of measured value or 0.1 FNU/NTU.

The sensor shall store on-board all the calibration data and other diagnostic information. At a minimum, the sensor shall have provision to store at-least 5 user calibration points.

The transmitter shall be suitable for outdoor installation with IP67 rating.

	Transmitter	
1	Transmitter Type	Four wire
2	Output	4-20 mA HART current
3	Supply voltage	100 / 115 / 230 V AC +10 / –15%,
4	Material	Field Housing : Polycarbonate
5	Display	LC display, two lines, with status indicators Graphic display : backlit ; transflective display ; user settable measuring menus ; red display for alarms
6	Electromagnetic compatibility	interference emission and interference immunity acc. to EN 61326-1:1998
7	Protection class of field housing	IP 67
8	Ambient temperature	–20 ... +60 °C
9	Self-Diagnostic feature	Required
	Sensor	
10	Type	Turbidity
11	Principle	Nephelometric measuring principle 90° NIR scattered light according to ISO 7027 / EN 27027
12	Measuring wavelength and range	860+/- 30nm 0..9999 FNU, 0..150g/l SS

13	Material	Sensor shaft : Stainless Steel 1.4404(AISI 316L) Optical window- Sapphire O-ring- EPDM
14	Max Process temperature	50°C
15	Max Process pressure	10bar
16	temperature sensor	Integrated NTC temperature sensor
17	Connection	Fixed cable connection
18	Ingres protection	IP68
19	Additional Certifications	Required
20	Resolution	0.001 FNU, 0.01 ppm, 0.1 g/l, 0.1%
21	Measurement error	<2% of meas. value (min. 0.02 FNU)

II. Online pH Measurement:

The pH online analytical instrumentation sensor shall be based on potentiometric measurement using glass sensor. The system shall comprise a combination pH sensor with integral reference electrode and temperature compensation, cabling, sensor mounting and a converter.

Sensors shall be either dip probe, flow cell or insertion types whichever is appropriate.
Dip probes shall be mounted on a floating or fixed corrosion resistant bracket. Insertion type sensors shall be removable without the need to drain down or shut down the process. Mounting of all sensors shall be arranged to prevent fouling and to allow easy access for removal for maintenance, cleaning and calibration.

Where the sensor is likely to be subject to poisoning, e.g. in an anaerobic situation where sulphide may occur, the sensor type shall be selected to be resistant to poisoning, e.g. by the provision of a double junction electrode. The sensor shall function over the pH range 0 to 14.

The system response time shall be not greater than 15 seconds for pH systems used for control and not greater than three minutes for monitoring only systems for 90% change in each case.

Overall accuracy shall be ±0.2 pH with a repeatability of ±0.1 pH. The sensor shall have digital communication based on inductive energy transfer; the sensor shall have inbuilt memory to store calibration data, and other additional diagnostic information. The transmitter shall be suitable for outdoor installation with IP67 rating.

	Transmitter	
1	Transmitter type	Four wire
2	Output	4-20 mA HART current
3	Supply voltage	100 / 115 / 230 V AC +10 / –15%,
4	Material	Field Housing : ABS Polycarbonate non corrosive
5	Display	LC display, two lines, with status indicators Graphic display : backlit ; transflective display ; user settable measuring menus ; red display for alarms

6	Electromagnetic compatibility	Interference emission and interference immunity acc. to EN 61326: 1997 / A1: 1998
7	Protection class of field housing	IP 67
8	Ambient temperature	–20 ... +60 °C
9	Diagnostic feature	Required
	Sensor	
10	Type	Glass electrode
11	Principle	Glass electrode Teflon diaphragm
12	Measurement range	0 - 14 pH
13	Material	Glass
14	temperature sensor	NTC / Pt100
15	Connection	Inductive digital connection with Transmitter
16	Ingres protection	IP68
17	Resolution	0.01pH, Temp 0.1°C
18	Calibration	Sensor to store calibration data , min/max pH range , Temperature
19	Measurement Error	± 0.5% of Measuring range

III. Online Chlorine Measurement:

Online chlorine analyser shall be based on amperometric measurement of active chlorine converted to free chlorine by means of pH compensation. The sensor shall have digital communication based on inductive energy transfer which will withstand moisture, corrosion and ensure reliable data transmission at all times.

The offered transmitter shall be IP67, Interference emission & immunity shall be as per EN 61326-1:2006.

	Transmitter	
1	Measuring parameter	Free Chlorine / Residual Chlorine
2	Transmitter type	4- wire
3	No of channel	Two channel (one for chlorine, one for pH)
4	Output	4-20 mA HART current
5	Supply voltage	100 / 115 / 230 V AC +10 / –15%, 48 ... 62 Hz
6	Material	Field Housing : ABS / Polycarbonate
7	Display	LC display, two lines, with status indicators Graphic display : backlit ; transflective display ; user settable measuring menus ; red display for alarms
8	Electromagnetic compatibility	Interference emission and interference immunity acc. to ISO EN 61326: 1997 / A1: 1998
9	Protection class of field	IP 67

	housing	
10	Ambient temperature	–20 ... +60 °C
	Sensor	
11	Principle	Amperometric measurement of free chlorine / Residual Chlorine with pH compensation
12	Measurement range	0,01 - 5ppm free chlorine
13	Material	Sensor shaft : PVC Membrane : PTFE Membrane cap :PBT (GF30); PVDF
14	pH compensation	pH sensor for compensation required
15	temperature sensor	NTC / Pt100
16	Connection	Inductive digital connection with Transmitter
17	Ingres protection	IP68
18	Resolution	0.01mg/l
19	Repeatability	+/- 1 %
20	Measurement Error	1 % of measured value
21	Mounting	Flow assembly

The residual chlorine analyzer shall continually measure the concentration of free chlorine residual present and, by control of the chlorine dosage rate, shall maintain the predetermined concentration. The residual analyzer shall have the capability to initiate high and low alarm locally and to SCADA.

IV. Online Dissolved Oxygen Measurement:

The online dissolved oxygen monitor shall comprise a dissolved oxygen sensor, cabling, sensor mounting and a converter. The sensor shall be provided with a suitable mounting either floating or fixed to locate the sensor in the required position. The mounting shall be specially designed to prevent fouling of the sensor and to permit easy access and removal of the probe for maintenance, cleaning and calibration. Where the sensor is to be sited in a hazardous area, it shall be certified as suitable for use in that area, according to its classification.

The system response time shall be not greater than 40 seconds for control applications and not greater than 3 minutes for monitoring only.

Accuracy shall be 0.01 mg/L or +/- 1% of measured value. This performance shall be maintained without manual intervention for a period of not less than 30 days. Auto calibration or auto cleaning techniques may be utilised to meet this requirement.

If auto cleaning is incorporated it shall not affect the accuracy of the instrument for a period greater than 5 minutes in any hour for a 40 second response system and 15 minutes in any hour for a 3 minute response system.

The converter shall be mains powered and suitable for wall mounting in a local enclosure or for door mounting within an MCC common control section. It shall include a digital display with manual selection of dissolved oxygen as mg/l or % saturation, and temperature in ^{o}C.

The range shall be selected manually. The controller shall include high and low set point control functions and high and low alarm functions. It shall also provide an output suitable for PLC system.

Automatic and manual calibration facilities shall be provided.

Measuring principle	Optical type
Measuring Range	0-10mg/l (0-10ppm)
Temperature compensation	Required
Operating temp range	–5 to 60 °C (20 to 140 °F)
Accuracy	0.01 mg/L or +/- 1% of measured value
Repeatability	+/- 0.5% of measuring range
Sensor material	Sensor shaft : Stainless steel 1.4571 (AISI 316Ti)Cap: POM.Fluorescence layer : Silicone
Temperature compensation	Required , internal
Cable/connector IP rating	IP 68
Sensor signal output	Digital communication with transmitter
Sensor memory	Required to store - calibration data, sensor model, serial number etc
Power Supply	100 to 230Vac +/- 15%, 50/60 Hz
Measuring signal input	Digital input from sensor
Measuring Range	To fit sensor range
Display	Graphic display : backlit ; transflective display ; user settable measuring menus ; red display for alarms
Enclosure IP rating	IP67, NEMA 4X
Enclosure material	Polycarbonate
Electromagnetic Compatibility	Interference emission & immunity as per EN 613261:2006, class A for industry

V. Online Suspended Solids Measurement

The method of measuring turbidity and suspended solids shall be with a dual-beam infrared/scattered light photometer. Other methods of turbidity and suspended solids measurement, such as four-beam or surface scatter methods, are not acceptable.

A) Performance Requirements
1) Measurement range
a) Turbidity: 0.001 to 4000 NTU
b) Suspended solids: 0.001 mg/l to 50 g/L
2) 2. Accuracy
a) Turbidity: <1% of reading or ±0.001 NTU, whichever is greater
b) Suspended solids: Less than 5% of reading
3) Repeatability
a) Turbidity: Less than 1% of reading

b) Suspended solids: Less than 3% of reading
4) Detection limit
a) Turbidity: 0.001 NTU
b) Suspended solids: 0.001 mg/L
5) Response time: Initial response 1 second
6) Units of measure:
a) Turbidity: User Selectable NTU, FNU, EBC, FTU and TE/F
b) Suspended Solids: User Selectable g/L, mg/L, ppm, or % solids
B) Operational Criteria
1) Sample flow velocity: 3 m/s maximum
2) Sample pressure: 6 bar maximum

The sensor shall provide sample color-independent measurement. The sensor shall be equipped with a self-cleaning device to prevent erroneous values and maintenance problems caused by biological activity, scum build-up, and gas bubbles. The sensor shall measures turbidity and suspended solids.

VI. Online Nitrate(NO3-N) & Ammoniacal Nitrogen (NH4-N) Measurement:

Online sensor shall be based on Ion Selective Electrode (ISE).The offered sensor shall not have any sampling or conditioning system, without any chemical requirements

Sensor output shall be in digital format for reliable and long distance transmission without loss of signal due to moisture or water

The transmitter shall be suitable for outdoor installation with IP67 rating.

Measuring principle	Potentiometric ion-selective electrodes for ammonium, potassium, nitrate and chloride, reference system and temperature sensor
Sensor type	Direct probe type in-situ mounting without any regent 3for operation
Sensor Ingress Protection rating	IP 68
Measuring range	0 to 100 mg/L NH4-N
	0 to 100 mg/L NO3-N
Material Cartridge	Stainless steel (1.4571), PVC, POM, ABS, NBR
Material Cleaning Unit	TPE, PUR, stainless steel (1.4571)
Material Sensor	Stainless steel (1.4571), ASA + PC, silicon, PVC and PU
Response Time	< 3 min
Calibration Method	Factory calibrated sensor cartridge (CARTRICAL), 1 and 2 point matrix correction
Sample Temperature	35 to 104 °F

Operating Temperature	-4 to 113 °F
Sensor signal output	Digital communication with transmitter
Power Supply	100 to 230Vac +/- 15%, 50/60 Hz
No. of measuring channels	* 1 or 2 channel /Multichannel
Display	Graphic display : backlit ; transflective display ; user settable measuring menus ; red display for alarms
Enclosure IP rating	IP67, NEMA 4X
Electromagnetic Compatibility	Interference emission & immunity as per EN 61326-1:2006, class A

VII. Online TDS measurement:

Measuring principle	Conductivity
Location	Influent at WwTP
Measuring Range	0.01 - 20 mS/cm
Temperature compensation	Required
Operating temp range	-20 to +135 °C
Pressure range	16bar max
Cable/Cable connector type	Plug in head
Cable/connector IP rating	IP 68
Cable length	15 mtr minimum
Sensor signal output	Digital communication with transmitter
Sensor memory	Required to store - calibration data, sensor model, serial number etc.
Sensor diagnostics	required
Power Supply	100 to 230Vac +/- 15%, 50/60 Hz
No. of measuring channels	1 channel
Measuring Range	To fit sensor range
Enclosure IP rating	IP67, NEMA 4X
Electromagnetic Compatibility	Interference emission & immunity as per EN 61326-1:2006, class A for industry

VIII. Online ORP Measurement:

Service	Measurement of Oxidation Reduction Potential
Repeatability	± 20 mV
Range	-2000 – 2000 mV/-1500 to + 1500 mV
Sensor	

Type	Immersion Type
Mounting	Locally
Installation hardware and Integral cable	Required
Probe material Operating temperature range Digital Sensor Pressure range Type of Ground Electrode	Suitable for Sewage application Analog Sensor: - 5 to 105 deg C - 5 to 70 deg C 0 to 6.9 bar Titanium ground electrode to eliminate ground Loop currents in the measuring electrodes.
Sensitivity	=/- 0.5 mV
Stability	2 mVper 24 Hours, non-cumulative
Flow rate	3 m (10feet) per second maximum
Built in temperature element	NTC 300 ohm thermistor for analyzer temperature Readout
Sensor Cable	4 conductor cable with one shield and polyurethane jacket rated to 105 deg C
Transmitter	
Type	Microprocessor Based having back Lit LCD display
Mounting	Field
Prefabricated integral cable for connecting sensor and transmitter	Required
Analog outputs	4–20 mA

13.22 Auto samplers

WwTP under this contract shall be provided with an all-weather refrigerated auto sampler's (2 Nos) with all required sample containers (at least 5 nos , comprising of all sizes available), reagents, media (as applicable) for the representative collection of samples to monitor influent and effluent sewage individually from the sewage treatment plant. The auto samplers shall be suitable for indoor and outdoor use. The equipment shall be UL certified.

The method of sample collection shall be via high-speed peristaltic pump for collection of the sample liquid.

Performance Requirements

1) Sample cooling: maintain sample liquid at 4°C (39°F) in ambient temperature to 50°C (122°F) maximum; accurate to ±0.8°C (±1.5°F).
2) Sample volume: shall be programmable in 10 mL increments from 10 to 10,000 mL.
3) Sample volume repeatability ±5% of 200 mL sample volume with: 4.6 m (15 ft.) vertical lift,
4) Sample volume accuracy: ±5% of 200 mL sample volume with: 4.6 m (15 ft.) vertical lift
   Operational Criteria
5) Operating temperature: 0 to 50°C
6) Storage temperature: -30 to 60°C

The auto samplers shall be interfaced with the plant main PLC system for complete monitoring of the auto sampler system parameters, control & monitoring from the PLC system.

13.23 Laboratory Instruments and LIMS system

The laboratory shall be equipped with LIMS software, Lab instruments, equipment, chemicals and other infrastructure that is necessary to perform the routine analysis for the parameters as detailed in table below.

WwTP Contractor shall submit the complete list of lab equipment required for full analysis of parameters to the employer's representative for approval. Contractor shall include in his offer supply of chemicals required for analysis along with proposed lab instruments and associated equipment, including for the O&M period as specified elsewhere in the bid document.

Minimum list Laboratory equipment to be provided are detailed as below:

Item No	Description	Unit	Quantity
1	Comparator test set for residual chlorine or chloroscope	No.	1
2	Multi Parameter (pH and Conductivity Meter)	No.	1
3	Mains operated pH meter completed with one calomel electrode and glass electrode	No.	1
4	Turbidimeter - Bench Model (Nephelometric Type)	No.	1
5	Turbidimeter - Hand held (Portable)	No.	1
6	Spectrophotometer	No.	1
7	Water bath with 6 to 8 concentric holes and discs, electrically heated	No.	1
8	Soxhlet extraction unit	No.	1
9	Kjeldahl digestion unit	No.	1
10	Hot plates	No.	10
11	Distilled water plant	No.	1
12	Demineraliser	No.	1
13	Refrigerator (320 litres capacity) double door	No.	1
14	B.O.D. incubator	No.	1
15	Muffle furnace	No.	1
16	Electric oven	No.	1
17	Magnetic stirrer	No.	1
18	Monopan balance with digital display	No.	1
19	Jar-Test apparatus with RPM controller and simultaneous addition of Chemicals in all jars	No.	1
20	Centrifuge	No.	1
21	Gas cylinder if gas supply is not available	No.	1

Item No	Description	Unit	Quantity
22	Fume cupboard/hood	No.	2
23	Field Test kit for cations and anions	No.	2
24	Depth sampler	No.	2
25	Online Total organic carbon analytical analyser with online feedback to LIMS and SCADA system	No.	1
26	Sieve shaker with standard sieves and Two pan balance, weighing up to 200gm samples	No.	1
27	Electronic Weighing Balance (Max. 10 kg)	No.	1
28	Durham tubes and Imhoff cones (1 lot)	lot	1
29	D.O meter	No.	1
30	Specific Gravity Meter (1.0~1.1 and 1.2~1.3)	No.	1
31	Consumables – disposable & reusable type	No.	1
Equipment Needed For Bacteriological Examination			
30	Hot Air Oven	No.	1
31	Autoclave	No.	1
32	Incubator 37°C or 44°C (Water/Air-Jacketed)	No.	1
33	Binocular microscope	No.	1
34	Digital pH Meter	No.	1
35	Pipette Box (Stainless Steel)	No.	10
36	Wooden Racks/Aluminum Racks	No.	5
37	Wire Baskets	No.	10
38	Cotton/ Aluminum Foils	No.	10
39	Burners (Bunsen) With Pilot Lamp	No.	3
40	Suction Flask (1 Litre Cap)	No.	2
41	Suction Pump	No.	1
42	Sampling Bottles	No.	10
43	Measuring Cylinders (1000 Ml, 500 Ml, 200 Ml, 100 Ml, 50 Ml, 25 Ml)	Set	3
44	Vacuum pump	No.	1
Bacteriological Media			
45	M. Endo Broth (dehydrated)	No.	1
46	Lactose or Lauryl Tryptose broth	No.	1
47	Mac Conkey broth	No.	1
48	Brilliant Green Bile Lactose Broth	No.	1
49	Total Plate Count Agar	No.	1
50	Peptone/Triyptone Water	No.	1

Item No	Description	Unit	Quantity
51	Laminar Air Flow Chamber	No.	1
52	Portable Density Meter	No.	1

The above indicated lab instruments are the minimum equipment to be provided at WwTP. If as per process requirements, any additional equipment is required, the Contractor shall supply the same at no additional cost.

The equipment shall be supplied with all the accessories that are necessary to make the equipment functional for analyzing parameters. Contractor shall include any additional equipment if necessary under his scope of work.

A. Laboratory Information Management software (LIMS):

The LIMS Software shall be installed pre-configured with regulatory, process, and other variables. The system shall be "user friendly" and shall use standard “Windows” conventions. The system on a minimum store plant data and provide reports and graphs for analysis and control. Database software as required shall be provided by the Contractor.
Licensing for concurrent client users and multiple facility support shall be included.

The Contractor shall include a computer hardware system as detailed in the specifications elsewhere. Operating system software shall be latest by Microsoft to suit the application software and onward connectivity to the plant SCADA system.

A full audit trail of all inserts, edits, deletes, and approvals shall be provided for all data points and system parameters. The system shall provide security features to ensure that only authorized individuals enter, view and modify data. Access levels shall be definable to restrict use of system level functions (such as user authorization), and to provide data access levels to restrict the use of data entry, data approval, data retrieval, data modification, database structure creation or modification functions.

Functionality
The software shall make available an unlimited number of user defined variables whose values may be defined as daily, hourly, 15-minute, or 1-minute parameters.
Text parameters and calculations shall be available. These calculated data values shall be stored in the database thus ensuring the consistency of the data and allowing the same data to be readily available for analysis. Historical equations shall allow definitions of the calculation by date.

Program shall store an unlimited number of user defined custom data entry forms or bench sheets with text and variables (one or more days) positioned as desired. Variable name, units, entry range, and permit limits shall be displayed when entering data to increase data accuracy.
An audible-visual prompt will activate when value is outside a specified range.
The software shall provide unlimited daily comments and comments attached to a sample value.
The software shall contain a complete statistical analysis capability including mean, variance, standard deviation, max and min, and confidence interval for any parameter in the Data Manager.
Trend charts shall be quickly and easily available for any variable.
The LIMS software shall be interfaced/integrated with the plant SCADA Historian for automatic collection of summarized data from historical file(s) as per requirement. The integration shall run with no user intervention.

UV Visible Pre-programmed Spectrophotometer:

UV Visible Pre-programmed Spectrophotometer for measurements of water Quality parameters and Spectral Analysis Shall be pre-programmed for more than 200 preprogrammed tests and special methods, 100 user defined methods, concentration, absorbance, transmission, factor, kinetics, 2-point calibration, scan, nephelometric turbidity measurement, different color measurement scales common drinking water testing parameters like residual chlorine, Iron, Hardness, alkalinity, fluoride and sulfate etc. The spectrophotometer instrument shall be a multi-wavelength, UV-Visible, single beam spectrophotometer designed for Water analysis. The instrument, depending on the test selection, shall automatically select the wavelength.

Readout modes shall include transmittance, absorbance, concentration, optional wavelength scan and time course graphs. Spectrophotometer should come along with the following reagents and accessories**:** Power supply, Operators manual, one pair 10mm rectangular path length cells and reagents for common drinking water parameters like residual free chlorine, Iron, sulfate, silica Low range and Fluoride for 1000 tests.

Technical Specifications:

Technical specifications of UV-Visible spectrophotometer	
Type:	Spectrophotometer with reference detector technology (RDT)
Light sources:	Halogen lamp (visible range) Deuterium lamp (UV range)
Optical system:	Monochromator
Wavelength range:	190 nm–1100 nm
Wavelength accuracy:	± 1 nm
Wavelength resolution:	0.1 nm
Wavelength calibration:	Automatic, Instrument should have inbuilt Holmium oxide filter
Wavelength selection:	Automatic, barcode, manual
Scan speed:	1 complete scan < 1 min
Spectral bandwidth:	< 2 nm
Photometric range:	± 3 Abs
Photometric accuracy:	0.005 Abs at 0.0–0.5 Abs; <1% at 0.5–2.0 Abs
Photometric linearity:	< 0.5% at 2 Abs; <1% at >2 Abs
Stray light:	< 0.05 %
Measuring modes:	More than 200 preprogrammed tests and special methods, 100 user defined methods, concentration, absorbance, transmission, factor, kinetics, 2-point calibration, scan, nephelometric turbidity measurement, different color measurement scales
Turbidity measurement:	Nephelometric turbidity measurement, 0.1–1000 NTU, instrument should have separate optics for turbidity measurement. Turbidity must be measured and shown for preprogrammed tube tests and customized methods in tubes and shown together with the result of the measurement to account for interfering turbidities (nephelometirc turbidity)
Preprogrammed special methods	Measurement of nitrate and SAC in UV range; nephelometric turbidity and TSS

Inspections equipment monitoring (IQC)	Instrument must have a preinstalled Holmium oxide filter to automatically check for wavelength accuracy. Control of lamps, photometric correctness and stray light. Measurement of standards, spike additions, multi determinations and dilutions
Color measurements	CIE conform color measurements must be possible, Measurement of color according to ISO7887 B,C ,APHA/HAZEN/PT-CO, ASTM 209,GARDNER,SAYBOLT (ASTM D156 ASTM 6045),Hunterlab, ASTM D1500,ICUMSA ,EP (Phr Eur) ,mgl2,Hess-Lves and Spectral data
User programs	100
Cuvette slot:	Universal cuvette slot for: Test tubes 16 mm OD Rectangular cuvettes 2 mm, 10 mm, 20 mm, 40 mm and 50 mm
Data memory:	Internal Micro SDHC card, 5000 measured data sets, 100 spectra, GLP conform (result, date, time, operator, dilution, comment, sample ID)
Display	HD 10 inch, anti-reflective cover glass with projected capacitive touch screen (PCAP)
Operating range:	10–40 °C, max. 80 % relative humidity (without condensation)

Laboratory pH Meter:

pH meter Technical Specifications	
Measurement Method	pH : Glass electrode method Temperature: Thermistor resistor
Display unit	Large Screen display Various display functions: Vertical/Horizontal screen switchable Graphic Display Easy-to-read menu Touch panel input Maintenance information
Measurement Item/Range	pH:0.000 - 14.000 Temperature: 0.0 - 100.0°C
Display Range	pH: pH-2.000 - 16.000 Temperature: -5 - 110.0°C
Display resolution switch	pH: 0.01pH/0.001pH mV (ORP): 1mV
Repeatability (Main body)	pH: ±0.006pH mV(ORP): ±2mV Temperature: within ±0.2°C
pH Temperature Compensation Range:	ATC(Auto Temperature Compensating): 0 - 100.0 °C MTC(Manual Temperature Compensating):0 - 100.0°C
pH Calibration:	JIS pH standard solution, US standard solution, customized standard solution, Max. 5 point calibration
Temperature Calibration	1 point calibration
Performance Guaranteed Temperature, Humidity	0 - 45°C, 20 - 85% or below(condensation-free)

Auto Hold Function Facility	Instrument should have auto hold function
Calibration History Creation Function	Latest one run
Interval measurement	Required

Bench top Multi parameter meter:

A multi parameter instrument capable of analysis of pH, ORP, dissolved oxygen, conductivity, TDS, salinity and temperature shall be provided. The instrument shall be capable of a quick response and have an intuitive user interface. The instrument shall have automatic temperature correction/compensation. Downloading and storage of data should be easy and convenient. It shall provide RS-232 interface and shall have a minimum of 150 points recall feature.

Technical Specifications:

Multi-Function Water Quality Technical Specifications	
Measuring method:	pH: Glass Electrode Method ORP :Platinum Electrode Ion :Ion Electrode Method Conductivity: AC 2-Electrode Method DO : Diaphram Polarographic Method Temperature : Thermistor Resistor
Conductivity Measuring Frequency	80Hz/3kHz, automatic selection
Electrode Inputs	2ch (pH/ORP/Ion/DO Electrode/Conductivity cell connectable)
Display Unit	Touch Panel Color Graphic LCD
Display	Selectable 2-ch Simultaneous Display or Single Only Display
Measuring Range	pH:0.000-14.000pH mV（ORP）: -2000.0~2000.0 mV Ion: Depends on the sensor Conductivity: Depends on the cell Resistivity: Conversion from conductivity Depend on the cell Salinity: Conversion from conductivity Concentration: Conversion from conductivity TDS: Conversion from conductivity DO: Depends on the electrode Saturation %: Depends on the electrode
Temperature:	0.0~100.0°C DO:0.0~50.0°C Ion: Depends on the sensor (No temperature compensation function)
Display Range	pH: -2.000-16.000 Temperature: -5-110.0°C
Repeatability(main unit):	
pH	±0.02pH
mV(ORP)	-2200.0~2200.0 mV
Ion(Manual/Auto range switching) (mol/L selectable):	ZOOM OFF 0.0 ～ 19.9μg/L, 20 ～ 199μg/L, 0.20 ～ 1.99mg/L, 2.0 ～ 19.9mg/L, 20 ～ 199mg/L, 0.20 ～ 1.99g/L, 2.0 ～ 19.9g/L, 20 ～ 199g/L, 200 ～ 1990g/L

	ZOOM ON 0.00 ～ 19.99μg/L, 20.0 ～ 199.9μg/L, 0.200 ～ 1.999mg/L, 2.00 ～ 19.99mg/L, 20.0 ～ 199.9mg/L, 0.200 ～ 1.999g/L, 2.00 ～ 19.99g/L, 20.0 ～ 199.9g/L, 200 ～ 1999g/L
Conductivity(Manual/Auto range switching):	0.0 ～200.0μS/m （ 0.000 ～2.000μS/cm） 0.000 ～2.000mS/m （ 0.00 ～20.00μS/cm） 0.00 ～20.00mS/m （ 0.0 ～200.0μS/cm） 0.0 ～200.0mS/m （ 0.000 ～2.000mS/cm） 0.000 ～2.000S/m （ 0.00 ～20.00mS/cm） 0.00 ～20.00S/m （ 0.0 ～200.0mS/cm） 0.0 ～200.0S/m （ 0.000 ～2.000S/cm） SI unit (S/m) and conventional unit (S/cm) selectable
Resistivity(Manual/Auto range switching):	0.005 ～2.000 Ω·m（ 0.5 ～200.0Ω·cm） 0.00 ～20.00 Ω·m（ 0.000 ～2.000kΩ·cm） 00.0 ～200.0 Ω·m（ 0.00 ～20.00kΩ·cm） 0.000 ～2.000kΩ·m（ 0.0 ～200.0kΩ·cm） 0.00 ～20.00kΩ·m（ 0.000 ～2.000MΩ·cm） 00.0 ～200.0kΩ·m（ 0.00 ～20.00MΩ·cm） 0.000 ～2.000MΩ·m（ 0.0 ～200.0MΩ·cm） 0.00 ～20.00MΩ·m（ 0 ～2000MΩ·cm） SI unit (Ω·m) and conventional unit (Ω·cm) selectable
Salinity:	0.00 ～ 4.04%（ NaCl） 0.00 ～ 42.40psu (PSS: Sea water salinity)
Concentration(Auto range switch):	0 ～ 2.000%, 0 ～ 20.00%, 0 ～ 200.0%
TDS(Manual/Auto range switching):	0 ～ 99.99mg/L, 0 ～ 999.9mg/L, 0 ～ 9.999g/L, 0 ～ 99.99g/L, 0 ～ 999.9g/L
Dissolved Oxygen:	0.00 ～ 22.00mg/L (High range membrane set (Option) 0.00 ～ 55.0mg/L)
Saturation %:	0 ～ 220.0% (High range membrane set (Option) 0 ～ 550%)
Temperature:	-5.0 ～ 110.0°C
Display Resolution Switching:	pH: 0.01pH/0.001pH mV: (ORP) 1mV/0.1mV Ion: 0.0μg/L～1990g/L (Maximum to 3 digits) 0.00μg/L～ 1999g/L (Maximum 4 digits)
Repeatability(Main body unit):	pH: ±0.002pH mV(ORP): ±0.2mV Ion: ±0.5% FS Conductivity: ±0.5% FS Resistivity: ±0.5% FS Salinity: ±0.5% FS Concentration: ±0.5% FS TDS: ±0.5% FS Dissolved Oxygen: ±0.03mg/L (Standard membrane)/±0.1mg/L (High range membrane)

	Saturation %: ±1% (Standard membrane/High range membrane) Temperature :within ±0.2
Temperature compensation:	pH Temp. compensation range: ATC（ Auto Temperature Compensation）: 0 ～100.0°C MTC(Manual Temperature Compensation): 0 ～100.0°C Conductivity Temp. compensation Range: ATC(Auto Temperature Compensation): 0- ～100.0°C MTC(Manual Temperature Compensation):0 ～100.0°C Dissolved Oxygen Temperature Compensation Range : ATC(Auto Temperature Compensation): 0 ～ 50.0°C
pH calibration	JIS pH Standard Solution, US Standard Solution,Custom Standard Solution, Max. 5-point Calibration
Ion calibration	Max.5-point Calibration
DO calibration	Auto Calibration（ Zero Span Calibration）
Temp. calibration:	1-point Calibration
Conductivity Concentration Conversion Setting:	2-10 points
Data Memory:	2000 data each channel
Analog Output:	pH:±700mV (pH0 ～ 14) mV(ORP): ±1V(0 ～ ±2000mV) Ion: 0 ～ 1VFS Conductivity/Resistivity/Salinity/Concentration/ TDS: 0 ～ 1VFS DO/Saturation: 0 ～ 1VFS Range(Ion/Conductivity/Resistivity/Salinity/ Concentration/TDS):100mV/Range Temperature: 0 ～1V(0 ～100°C)

Laboratory Turbidity Meter:

Turbidity meter shall have pre-programmed features for measurement of turbidity with ratio color correction covering the range from 0 to 10,000 NTU with auto signal averaging. Turbidity meter should come along with the following accessories: A complete set of calibration standards (0.02, 10, 100, 1750 NTU), Two measuring corvettes with light shield caps, operators' manual, and plug in power adaptor.

Technical specifications:

1	Principal of operation	Nephelometric
2	Light Source	Infra-red
3	Extended auto ranging	up to 10,000 NTU 0 - 2,450 EBC 0 - 10,000 FNU 0 - 10,000 FAU
4	Resolution	NTU on lowest range

5	Accuracy	± 2% to ±10% of reading (in 3 ranges)
6	Response time	less than 6 seconds
7	Sample size	30 ml
8	Air purge	connection for external dry air supply
9	Auto alert calibration prompt.	
10	Outputs	RS-232 Serial Port
11	Reusable Calibration Standards	
12	Certification	UL, CSA, CE, ISO7027

Instrument should have option for connecting flow thru cell.

Portable Turbidimeter

The integrated algorithm of scattering and transmission not only makes the measurement of low turbidity more stable, but also realizes wide testing ranges for the instrument (low, middle and high measuring ranges. Integrating algorithm of Scattering(90°) and transmission

Technical Specifications:

Ranges	0-1000NTU
Accuracy	±5%
Drifting	≤±1.5%
Repeatability	≤1%
Resolution	0.01NTU (0-9.99NTU) 0.1NTU (10-99.99NTU) 1NTU (100-1000NTU)
Stray Light	< 0.02 NTU
Sample required	15 ml
Detector Silicon	photodiode
Storage conditions	-25 to 50 °C（instrument）
Operating conditions	0 to 50 °C; 0 to 90% relative humidity (noncondensing)

Dissolved Oxygen Meter:

Technical Specifications:

Range	:	0.00 ～ 22.00mg/L
Repeatability	:	±0.03mg/L (Standard membrane
Resolution	:	Temperature :within ±0.2
Method	:	Membrane Polarographic
Salinity range	:	0.00 ～ 4.04%（NaCl） 0.00 ～ 42.40psu (PSS: Sea water salinity)

DO/Saturation	:	0 ~1VFS
Dissolved Oxygen Temperature Compensation Range	:	ATC(Auto Temperature Compensation): 0 ～ 50.0°C

Residual Chlorine Meter:

The instrument should be a handy model which should be capable of analyzing three water quality tests. Instrument should be simple to use and should display error messages as and when they occur. The instrument should be pre-programmed to conduct the following tests:

Type:	LED photometer with 3 interference filters
Wavelengths:	450 nm, 530 nm, 590 nm
Wavelength accuracy:	± 2 nm, bandwidth at half transmission 10–12 nm
Measuring modes:	Pre-programmed tests
Cuvette holder:	Tubes 16 mm OD
Memory:	50 results
Display:	Backlit graphic display, result with unit
Operation:	Self-explanatory menu guidance, plastic foil keypad test selection via parameter lists
Power supply:	3 AA batteries, rechargeable batteries, USB interface; optional internal accu-pack
Preprogrammed Methods	chlorine, chlorine dioxide, pH, fluoride and iron
Supply	DPD Chlorine reagent for 100 test

In addition, Instrument should include the following**:** Intransclam packing with reagents for 100 free chlorine tests**,** Crushing rod and 2 test cells. The instrument should be provided with a operations &instructions manual.

Portable Density Meter:

Type : truly portable measurement, visibility: both indoors and outdoors to be achieved.
Accuracy : ± 0.001 or better
Storage Capacity : above 1000 results.
Multiple sequential measurements shall be possible with the meter. Meter's sample tube is to be dipped directly into the sample for measurement.
Meter shall be Battery Operated; Lithium ion Rechargeable and removable type batteries shall be used. Temperature Compensation shall be an automatic or by using a user-defined temperature correction coefficient.
If required, meter shall have built-in sampling pump and interface to PC for data acquisition & logging,

13.24 Associated Lab Equipment:

Sterilizer, Autoclave:

Purpose: For sterilization of glassware and culture media for bacteriological analysis.

Double wall construction with inner & outer chamber made of Aluminum. Electrically heated by means of superior quality emersion heaters with working pressure 15 PSI. Inner Chamber Size: 550X750mm. Rating: 6.0 KW, Volume: 175litre.

Balance, Analytical (Electronic):

Purpose: For preparation of standard solutions used in chemical analysis.

Specifications: Should be based on E.M.F.C. Technology

Type: Electronic single Pan, Capacity: 200 mg, Resolution: 0.1 mg, Stainless steel weighing pan; Pan Size: 100 mm Diameter, Display: Sharp, Clear LED Display and Standard bi-directional RS232C interfaces. Multiple weighing Units: Grams & Carat. It should have auto calibration facility, Overload protection and auto zero facility. Balance should come along with Set of certified calibration weights, Voltage stabilizer, Dust proof cover, Operational manual and necessary tools.

Centrifuge: Purpose: For separation of suspended matter from suspensions.

Specifications:

Max. Speed	20000 RPM, Max. RCF: 34500, Max. Tube size: 100 ml, Max. Capacity: 400 ml. Width: 450 mm, Depth: 470 mm, Weight: 35 kg
Connected Load	0.75
Rotor Angle Head	8x50 ml
Speed regulation	Step less variable speed control.
Digital Speed indicator	1 to 99 minutes digital timer with by-pass switch for infinite time run.

Incubator Bacteriological:

Purpose: For incubation in bacteriological analysis

Double walled cabinet. Outer wall should be made of mild steel, inner wall of stainless steel, lagged with a special insulating material. The inside door should be made of glass panel set in a metal frame fitted with a felt gasket and be fastened by a ball catch.

Temperature range	°C above ambient to maximum 60°C.
Accuracy	±2°C
Size	600X600X600cm
Rating	1000Watts.
Purpose	For cooling and storage of (standard) solution in a laboratory

Specifications:	
Type	Vertical double door

Capacity	Approx: 280 litre.

Water Bath, General Purpose:

Purpose: For enhancement of chemical reaction in various analyses and evaporating of water from samples

Specifications: Doubled walled construction Fitted with imported thermostat of 30 Deg C to 110 °C Accuracy of +/- 1 DegC.Working Temp. from 5 Deg C above ambient 80 °C made of double wall, stainless steel construction, with glass wool
Capacity: 15 Ltrs

12 holes of 75 mm dia , 2000 Watts

Ware Purifier, Distillation Unit For Laboratory requirement (Automatic)
Applications Type III water maker
Instrumental Analysis & reagent preparation
Feed Water Specifications
TDS : 500 PPM MAX
Fe ,Mn : NIL
Free Chlorine : NIL
Silica : <20 PPM
Inlet Pressure : 0.5 – 2.0 kg/cm
Product Water Specification:
Nominal Flow To Storage Tank:10 Ltr/Hr
Pure Water Resistivity (Tpye II) : >1 MD
Pure Water Conductivity(Tpye II) :1 µS/cm
Turbidity: 1 NTU
Total Organic Carbon (TOC) : <200 ppb

Rectangular heating Plate with cast Iron top
Shall be used for continuous heating up to 350ºC. The body shall be of made of P.C.R sheet painted. Attractively with good stove enamel Top rectangular cast iron Plate has insulated elements. To work on 220/230V AC supply
Size (L x B x H):25 x 30 x 15 cm (10”x12”x6”), With E/R

Water Still Automatic (Wall Type)
Compete made of S. Steel provided with automatic ejection type immersion heaters to provide pyrogen-free water
Capacity: 4 Liters, Load: 4 KW

Demineraliser
Two Bed Capacity 100 lt/hr

Refrigerator--Double Door
Capacity: 280 Liters

Muffle Furnace Rectangular

Light weight with ceramic fibre wool insulation the outer casting shall be made of double walled thick P.C.R.C. sheet Re attached with thick perforated sheet on the bottom portion, painted with attractive stove enamel.

Heating elements shall be made of KANTHAL A1 wire of coil form embedded on the muffle with high grade refectory cement and backed by high temperature cer-wool insulation which avoids loss of energy. The apparatus shall be complete with one pyrometer, thermocouple & silver thermal fuse.

Laboratory Oven

Double walled construction. Inner chamber made of Aluminum/ S. Steel. Outer body made of mild steel is powder coated/painted. Temperature shall controlled by Microprocessor based PID Controller from 50-250C .Provided with air circulating fan. The gap between the inner & outer chamber is filled with high grade glass wool to avoid the thermal losses. Perforated adjustable trays. Two pilot lamp on/off switch. To work on 220/230 V.AC.
Size: 45x45x45cms

Magnetic Stirrer

With Hot Plate, Capacity: 2 liter

Jar Testing or Multiple Spindle Stirrer

This unit is designed for flock information fest in water treatment plants with variable speed from 25 to 150 RPM 1/20 H.P. geared motor whole unit is mounted on mild steel housing with tube lights support by four support or 9½" height. S. Steel stirring peddle 1/3" are attached to rods 10" long ¼" dia motor with lifting knob at the top. Locking collars at stirring rods permits adjustments of paddle height spacing of 6" between rods, permits use of 1000 ml beakers arresting directly on bench. Complete with ON/OFF switch.

Mini Gas Cylinder with Regulator

Fume Hood

Thick wooden board fabricated, outer is finished with Laminated Mica and inner duly painted, designed so as throw out all toxic/charmful vapors, thus protecting costly instruments and the person working in the lab. Working table top is fitted with stainless steel top, provided with SS sink and Tap. The front door moves vertically up & down with concealed counter balanced weight/by Hingers the unit is fitted with fluorescent light and a gas cock for gas/air supply. The space under the work station can be provided with switches for exhaust system and b fluorescent lights. Workable on 220 Volts AC supply.
Working Size: 4'x2'x2'.

EQUIPMENT NEEDED FOR BACTEROLOGICAL EXAMINATION

Hot Air Oven

Double walled construction .Inner chamber made of S.Steel. Outer body made of mild steel is powder coated/painted Temperature thermostatically controlled by hydraulic thermostat from 50°C to 250°C Elements are at the bottom and sides. Built in 'L' shape thermometer the gap between the inner & outer chamber is filled with high grade glass wool to avoid the thermal losses. Perforated adjustable trays. Two pilot lamp on/off switch. To work on 220/230 VAC Size: 350x350x350mm (14"x14"x14").

Autoclave Vertical

Outer body made of thick mild steel finished oven baked enamel Inner chamber will be thick stainless steel. The chamber is absolutely leak-proof and it can be operated at any selective point in between5 to 20 pound/Sq. inch The instrument is equipped with pressure gauge Pressure release valve, safety valve, water

level indicator and perforated S.S. basket complete with cord and plug The lid is made of thick mild steel sheet duly lined with stainless steel with pedal lifting arrangements and radial locking devices to work on 220/230V AC single phase supply Inner Chamber Dia x Depth:300 x 500 mm,Load:2.0KW.

Incubator 37°C or 44°C (Water/Air-Jacketed)

Triple walled construction. Inner chamber made of Aluminum/ S. Steel. Outer body made of mild steel is powder coated/painted. Temperature is controlled by Microprocessor based PID Controller from Ambient + 5 to 60X.Provided with air circulating fan . The gap between the inner & outer chamber is filled with high grade glass wool to avoid the thermal losses. Perforated adjustable trays. Two pilot lamp on/off switch. To work on 220/230 V.AC.

Binocular microscope

Binocular Microscope : With quadruple revolving ball bearing nosepiece , low drive Co-axial mechanical stage, binocular head with hard coated prisms, graduated precise slow motion, with built in light arrangement having 6v-20w halogen lamp and solid state light control arrangement complete in box with following optics Eye pieces WF10 x & H 5x (Three pairs) 3 pairs Objectives 4x, 10x, 40x (SL), 100x (SL) oil.

Pipette Box (Stainless Steel)

Aluminum Racks 18mm, 12 holes

Wire Baskets Size: 140x120x110mm

Aluminum Foils (roll of 9 mtr.)

Burners with pilot lamp

Suction Flask (1 Litre Cap)

Suction Pump

Promivac`100% Oil free Diaphragm/Piston type Vacuum-Pressure pump, portable, single/double head, complete in all respect as per following specifications.
Type : Diaphragm
Head : Double
Displacement: 45 liters. /Min
Vacuum : 27”Hg. (100 mbar)
Pressure : 55 psi
H.P. : ¼, single phase, 220-240 V
Vacuum gauge with Regulator

Sampling Bottles

Measuring Cylinders (1000 Ml, 500 Ml, 200 Ml, 100 Ml, 50 Ml, 25 Ml)

Vacuum pump

100% Oil free Diaphragm/Piston type Vacuum-Pressure pump, portable, single/double head, complete in all respect as per following specifications
Type : Diaphragm
Head : Double
Displacement: 45 liters. /Min

Vacuum : 27”Hg. (100 mbar)
Pressure : 55 psi
H.P. : ¼, single phase, 220-240 V
Vacuum gauge with Regulator

Laminar Air Flow Cabinet

Laminar air flow cabinets able to create particle free air of Class-II standard. The cabinet is fabricated out of board with sunmica laminated exterior. The working table is made of thick board which is also sunmica at top. Laminar flow is based on principle of double filtration of air. Atmospheric air will be drawn through the pre-filters by heavy duty blowers. Filtered air than passed through highly effective HEPA Filters with 99.97% efficiency for particulates of 0.3 micron or larger, which can filter almost all air born contaminants such as dust, fungal spores, bacteria etc. Double filtered laminar flow air will blow horizontally/vertically through the working table at a nominal velocity or approx 90 Fts/min. Heavy duty blowers dynamically balanced with 0.25 HP electric motor are mounted on shock resistant base of cabinet or anti-vibration pads, operate on 230 +/- 10 volts, 50 Hz AC supply. Shadow less uniform lighting is provided within working space (100 feet candles). Unit will be mounted on caster wheel and supplied with high quality plug and cord
Size: 3 x 2' x 2

FURNITURE

The laboratory furniture shall be modular in design, made of mainly 18 SWG CRCA/GI Sheet in panel form to get the best and full coverage of powder coating and in CKD – Completely Knocked Down construction so can be installed at site as per approved layout. Laboratory Modular Furniture includes Pedestal Frame Structure, Under Bench Storage Modules and Work Top / Surface.
The furniture shall be designed of height 900mm for standing posture and 750mm for sitting posture. Height will be maintained as per the site requirement. All metal components / parts shall be 7tanks pre-treated (with premium chemicals and DM water) and 50-60 micron Epoxy Polyester Coated with automatic robotic spray gun.

1. WALL BENCH – 1 (20 SWG CRCA/GI sheet with PU powder coated)

Overall Dimensions L=6000m,W=750mm,H=900mm
It consists of following.
Base Cabinet L=600mm 1 drawer 2 shutter – 10 No’s
Base Cabinet L=600mm 2 shutter – 10 No’s
Granite Top L=6000mm W=750mm – 1 No
PP Sink – 2 No’s
Three way water tap – 2 No’s
Electrical raceway - 5+10

2. WORKING TABLE – 1 (20 SWG CRCA/GI sheet with PU powder coated)

Overall Dimensions L=1200m,W=750mm,H=750mm
Shall consists of following.
Base Cabinet L=600mm 1 drawer 2 shutter – 1 No
Foot rest L=600mm – 1 No
Granite Top L=1200mm W=750mm – 1 No

3. Revolving Stools

4. Revolving Chairs

5. Almirah for Storage

6. White-board & pens

Work Tables and Benches

Minimum of 1set of work table and chair per staff shall be provided for the laboratory and office staff. The furniture and chairs shall be of ergonomic design. This work table along with the LIMS shall be isolated within a Laboratory to form a cabin with a glass partition.

The work tables shall be along the wall and shall be provided with adequate storage capacity and open glass shelves on the top to provide additional space for storage of chemicals and stock solutions.

A fume cupboard with ventilation hood shall be provided to prevent spreading of toxic and irritant fumes and odours into other parts of the laboratory. Forced ventilation with exhaust fans shall be provided. The wall space and offsets shall be convenient to locate cabinet, benches, hoods, incubators alongside without any loss of floor space.
Contractor shall also provide Almira for document storage purpose
Contractor shall also provide almirah with lock facility for document storage purpose. Separate cabinet shall be provided for storage of PPEs, Lab coats etc.

Consumables for Laboratories
Consumables must be replaced regularly because they wear out or are used up. Lab Consumables maybe disposable and reusable.

Contractor shall supply sufficient quantity of consumables required during testing & commissioning period as well as during entire Operation & maintenance period of contract.
The consumable includes but not limited to litmus papers, bags, Labels & markers, cleaners, bottles & caps, Gloves, Tapes, Lab containers, dishes, knives & cutters, gloves, glassware, funnels, flasks, Scalpels, Scissors & Shears, Tongs, Timers, stoppers-counters, films & foils, beakers, Pipettes, Pipettors & Tips, Crucibles, Forceps and Tweezers, white board pens, permanent markers & most importantly Reagents & chemicals, gas Cylinders etc.

Laboratory Waste Disposal Procedures. Waste disposal shall be managed by the appropriate party and it typically includes the following categories: municipal waste, hazardous waste, biological waste and sharps.

Chemical Laboratory safety measures
Personal protective equipment and safety devices must be provided to all employees under the appropriate circumstances and employees have the responsibility of properly using such equipment. According to safety regulations, it is obligatory to wear a lab coat and closed shoes in the lab, safety glasses and gloves if necessary.

Laboratories may contain certain inherent dangers and hazards Laboratories shall also be well equipped with all sort of safety measures which shall include Fire extinguishers, First Aid Box, provision for eye wash, Safety sign-boards, warning etc.

Labels and warning signs should alert employees to potentially hazardous materials and allow those unfamiliar with the laboratory surroundings to identify hazardous chemical use and storage areas, safety facilities, emergency equipment and exits and aid emergency response personnel.

13.25 Online Real Time Multi Parameters Continuous Monitoring System for Influent and Treated Sewage Parameters for the WwTP

The online real time multi parameter continuous monitoring system (2 Nos shall be provided for WwTP) shall be able to measure the below indicated parameters on a minimum through extractive method only for ease of operation, calibration & troubleshooting and shall have the capacity for future expansion.

At a minimum the parameters specified in Part 5 Volume 2, Section 7 of the tender document shall be considered for the inlet and outlet of the WwTP

The system shall have capability to accommodate any additional parameters viz. Turbidity, Conductivity, TDS, Oil in water, etc. as may be required by the end user, from time to time.

The Contractor shall provide complete Sample handling system, including all necessary accessories that require to meet the requirement to measure the multi-parameters as specified in Part 5 Volume 2, Section 7 of the tender document.

The online real time multi parameter continuous monitoring system shall be equipped with inbuilt automatic cleaning facility. Required mechanism & cleaning solution for automatic cleaning shall be supplied for the entire duration of the operation and maintenance period. For the air-pressure cleaning system, Air Compressor of required capacity along with required air pipe line etc. shall be supplied.

Further, WwTP shall be equipped with Auto samplers at the inlet and treated sewage point. Each of the online real time multi parameter continuous monitoring system shall be integrated with the Auto sampler. The online real time multi parameter continuous monitoring system is required to communicate with the auto sampler for exceedance sample so that it can store sample in Auto sampler for Lab analysis. This is to ensure that the sample taken by the auto sampler and the multi parametric analyzer are of the same time period. Contractor shall not the importance of this requirement and include the same in datasheet submission for both auto sampler and real time monitoring equipment.

All required calibration standard chemicals & reagents, are required to be provided for a complete duration of the operation and maintenance period for all mentioned parameters.

The online real time multi parameter continuous monitoring system shall accept the input signal from existing outlet Flow meter at the sewage treatment plant for display as well as Data transmission. Required cabling, any other hardware to achieve the same shall be under the Contractor scope of work under this contract.

The online real time multi parameter continuous monitoring system shall be equipped with USB port for download of stored measurement data along with diagnostic files for easy troubleshooting. The minimum data storage for all the parameters shall be three months in the non-volatile memory of the equipment.

The online real time multi parameter continuous monitoring system shall be equipped with suitable communication ports for integration/ provide data to sewage treatment control system (PLC based SCADA system).

The online real time multi parameter continuous monitoring system shall have multiplexing facility to add minimum five sample streams to allow connection of additional sample stream for future requirements.

The Contractor shall provide mandatory spares along with the online real time multi parameter continuous monitoring system for the entire contract which shall include:

1) 1 No of Electronic circuit Boards,
2) 1 No of Display Board,
3) Tubing's,
4) 1 No of Cleaning Pump,
5) 1 No of Spectroscopic Modules & all other required spares.

Technical requirements:

A) COD (Chemical Oxygen Demand)

Measuring Principle	UV-VIS Spectroscopy with entire spectrum scanning between 180 nm to 800 nm.
Measuring Range	0 –1000 mg/l(Min)
Accuracy	± 2% on standard solution
Repeatability	± 1 mg/l
Response Time	< 5 min.
Cleaning	Automatic cleaning

B) Ammoniacal Nitrogen (NH4-N) and Nitrates (NO3-N)

Measuring Principle	UV Absorption after gas stripping. Measurement should be in gas phase for completely interference free measurement.
Measuring Range	0 – 100 mg/l (Min)
Accuracy	± 5% on standard solution
Repeatability	± 0.2 mg/l
Response Time	< 5 min.
Cleaning	Automatic cleaning

C) Total Suspended Solids (TSS)

Measuring Principle	UV-VIS Spectroscopy with entire spectrum scanning between 180 nm to 800 nm.
Measuring Range	0 – 2000 mg/l
Accuracy	± 2% on standard solution
Repeatability	± 2 mg/l
Response Time	< 5 min.
Cleaning	Automatic cleaning

D) pH

Measuring Principle	Electrochemical Method
Measuring Range	0 – 14 pH

Accuracy	± 2% on standard solution
Repeatability	± 0.01 pH
Response Time	< 1 min.

E) Dissolved Oxygen

Measuring Principle	Optical Method
Measuring Range	0 – 20 mg/l
Accuracy	< 1 % of full scale
Resolution	< 0.01 mg/L
Precision	< 0.02 mg/L
Response time	< 1 min
Cleaning	Automatic cleaning

F) Temperature

Measuring Range	0 – 80”C
Accuracy	< 0.1 C
Resolution	< 0.1 C
Precision	< 0.1 C
Response time	< 1 min
Cleaning	Automatic cleaning

G) Online Real Time Multi Parameters Continuous Monitoring System for Influent and Treated Sewage Parameters system

Operating Pressure	Contractor to specify
Operating Temperature	Sample temperature: 0 ºC to 80 ºC
Operating Flow	Contractor to specify
Enclosure protection	IP65 minimum
Communication	RS232 or RS485 output - USB port required for USB/ pen drive connection.
Memory	As specified in the technical requirements in this document
Display	Color LCD, with LED backlight Resistive touch screen display.
Measuring time/ Response time	1 Min Programmable
Measuring Cycle	Continuous.
Power supply	90- 264 VAC 50/60 Hz
Cleaning method	Equipment should have facility to start cleaning cycle automatically as per user defined time interval.

Calibration requirement	Required. Shall have auto zero calibration facility. Equipment shall have facility to start auto zero calibration as per user defined time interval. Span Calibration: Shall perform as per laboratory measurement data.
UV Light Source	Xenon Flash Lamp
Expandability of measurement	Equipment shall have facility to expand measurement to meet future compliance requirements (if any). Equipment shall have capability to add parameters like NO3 & Conductivity, turbidity at no extra cost. Equipment shall have capability to add other parameters as mention below & should be facilitate to upgrade with Minimal cost using same enclosure. Oil in Water: Measurement Technique by UV Fluorescence Chromium, Phosphate. Measurement Technique by Colorimetric TDS/Conductivity: Measurement Technique by Electrochemical.
Additional Features	Should have Automatic Zero calibration facility which can be programmable as per user defined interval.
	UV source should be Xenon flash lamp with life more than 10 years.
	Equipment should be cabinet type (IP 65) for easy operation, maintenance & troubleshooting. If not the complete instrument shall be provided with IP-68 enclosure
	USB port for downloading stored measurement data.
	Should have robust flow cell which allows very high level of suspended solid without clogging and also suitable for highly corrosive water Sample.
	Should have automatic turbidity compensation facility by a dual wavelength
	USB port is required for recorded measurement download, screen copy function (easy troubleshooting) & software update

13.26 Particular Control & Automation Requirements

A. General

This part covers the Particular requirements for the design, supply, installation, Inspection and testing of Programmable Logic Controllers (PLC) and Supervisory Control and Data Acquisition (SCADA) and associated plant and materials.

13.27 Design, Supply and Construction Requirements

WwTP PLC shall be provided as a Hot-Standby configuration to perform combinational and sequential logic functions, status monitoring and reporting functions with counter and timer facilities.

In particular, the following configuration shall be applicable across the WwTP.

a) WwTP Main Plant PLC: Hot standby PLC

Main PLC system shall comprise of necessary hot standby PLC processors, Simplex input/output (I/O) modules(duplex I/O modules shall be provided for only critical inputs/outputs, the same shall be decided during detail design engineering), redundant communication interface modules, redundant power supply modules and Human-Machine Interface (HMI) required performing the desired functions.

PLC shall have the following attributes as a Hot Stand-by Controller.

- carry out sequential logic implementation for operations of plant;
- carry out computation and interfacing for data acquisition, data storage and retrieval;
- it shall accept downloaded program from a programmer;
- it shall have different functional modules to perform the desired functions;
- it shall scan the inputs in time cycles and update the status of its outputs.

The PLC system shall be expandable, OPC Compatible and shall be modular in construction, so as to be capable of future expansion without hardware modifications. PLC s shall be microprocessor based. PLC s shall use standard known protocols and structures for communication outside the system.

In case of system failure or power supply failure the outputs shall attain a predetermined fail safe condition (this shall normally be 'off').The PLC used shall have a proven record in the type of application concerned and in the prevailing environmental conditions.

All PLC based Systems should be housed in air conditioned environment. The Contractor shall submit the sizing calculations for the air conditioning system for review and approval.

The Contractor shall refer the approved vendor list for the PLC system and hardware, elsewhere in this document.

b) Remote input/output modules (RIO)/Panels

The PLC system shall consist of field remote input/output modules (RIO) and panels. Each RIO panel shall consist of redundant communication modules, power supply modules, minimum 15" color panel mounted HMI with touch screen functionality. It shall be possible to view and acknowledge the alarms and view set points for the particular process from the HMI etc.

c) I/O Modules:

Standard rack mounted plug in I/O modules shall be provided. I/O Modules should be of the same series as the PLC CPU. Refer the approved vendor list for the PLC system and hardware, elsewhere in this document.

Field wiring shall be terminated in screwed terminal blocks and interconnected to the processor I/O system with prefabricated cables and plug in card type connectors. I/O Modules should be hot swappable.30% extra modules of installed capacity for each type of module shall be provided as spare. In addition to the above, provision shall be made for future expansion of additional 30% extra I/O modules of the installed capacity in the panel. The panel drawings shall reflect the same.

I/O modules shall be as follows:

a) inputs shall be opto isolated.;
b) filters shall be provided for noise rejection;
c) output status shall be indicated by an LED;
d) all outputs shall be fuse protected and have fuse failure indication the fuses may be mounted externally from the output module;
e) all the modules shall be of addressable type.
f) Ethernet I/O modules shall be connected to the PLC by on board Ethernet 10/100 Base T connection port. Ethernet I/O modules shall support multiple communications including TCP/IP and Modbus ASCII and RTU allowing connection to any device supporting these protocols over standard Ethernet backplane.

Each PLC shall have memory protected built in historical archiving/data logging of system alarms & events and process variables. Data logger shall be able to log data based on time or an event. PLC shall have enough memory allocated to allow 200,000 time and data stamped discrete and /or analog values to be archived. The historical archive shall allow the oldest data to roll off the system as memory is used keeping the 200,000 most current data points available. Process point time stamping frequency shall be selectable within the configuration software. It shall be possible for the archived data to be exported in CSV format allowing use with standard spreadsheet and data software applications

The PLC system shall be expandable, OPC Compatible (OPC should be a built in feature of the software and hardware. No external software patch or hardware module is allowed) and shall be modular in construction, so as to be capable of future expansion without hardware modifications.

d) Dual Redundant Processors (CPU)

The master station shall be provided with two identical central processors configured such that they operate in Hot-Standby mode.

Redundant system with hot back up redundancy feature should be built in the CPU. Software engineered hot backup systems are not acceptable. CPU should have the memory expansion capability up to 7 MB.

SCADA connectivity with the CPU will be on dual Ethernet network (10/100 Mbps with open Modbus TCP/IP protocol). On the event of hardware failure in primary system the standby system will provide dual connectivity with the SCADA.

Redundancy of switch for SCADA (industrial grade managed switch) connectivity is to be provided. PLC CPU and I/O modules shall be of the same logic family.

The system shall be designed and implemented such that when the Main processor fails, the Standby one shall automatically take over. The changeover shall be seamless, smooth and without any time delay and shall not cause any disruption to the overall distributed control system and to the ongoing processes.

The PLC system shall be expandable (OPC Compatible) and shall be modular in construction, so as to capable of future expansion without hardware modifications.

The system hardware, application software and database shall be sized to accommodate a total of 50% increase in signal capacity and up to 100% increase in an individual zone.

PLCs shall be microprocessor based. PLC s shall use standard known protocols and structures for communication outside the system. In case of system failure or power supply failure the outputs shall attain a predetermined fail safe condition (this shall normally be 'off'). The PLC used shall have a proven record in the type of application concerned and in the prevailing environmental conditions.

Application logic programs shall be fully compliant with all five logic development methods detailed in IEC 61131-3. The PLC shall be powered by two independent sources provided by the UPS system and all internal operating supplies shall be derived from the UPS.

The power supplies, I/O modules, CPU and communication modules shall be monitored by the PLC and shall be available by report. The same shall be monitored on the SCADA screen.

During the times of the battery discharge, the PLC shall initiate an orderly self-shutdown and automatically restart on the main power restoration without the need for reloading or initiation of any kind. The PLC shall comply with the specification specified elsewhere in this specification.

e) Central Processing Units

The central processing units (CPU) shall be a high performance processor with modular configuration suitable for real time process applications. The following additional features shall be provided:

Redundant system with hot back up redundancy feature should be built in the CPU. Software engineered hot backup system will not be not acceptable. CPU should have the memory expansion capability of minimum 7 MB.

SCADA connectivity with the CPU will be on dual Ethernet network (10/100 Mbps with open Modbus TCP/IP protocol). On the event of hardware failure in primary system the standby system will provide dual connectivity with the SCADA.

Redundancy of switch for SCADA (industrial grade managed switch) connectivity should be provided. Communication between CPU and peripherals shall be by an I/O bus. The individual device, interfaces shall be capable of being plugged into the I/O bus. On resumption of power following a power failure the PLC shall automatically restart its controlling function.

CPU shall have a real time clock capability to accept a time synchronization pulse and adjust its internal clock with the pulse. CPU shall have extensive self-diagnostic facilities and watch dog timers to identify faults at card levels

f) Memory Unit

Memory unit shall comprise of highly reliable memory chips which are industry standard, proven design with fast random access and suitable for operation in process environments. Main memory shall be modular and facility shall be provided for the upgrading and expansion of memory to meet future demands.

Not less than 50 % spare program memory and data memory space shall be provided. System initialization and application software shall be stored in EEPROM or EPROM. Operating data shall be stored in a RAM fitted with an internal battery backup.

g) I/O Modules

Standard rack mounted plug in I/O modules shall be provided. I/O Modules should be of the same series as the PLC CPU. Field wiring shall be terminated in screwed terminal blocks and interconnected to the processor I/O system with prefabricated cables and plug in card type connectors. I/O Modules should be hot swappable.

30% extra modules of installed capacity for each type of module shall be provided as spare.

I/O modules shall be as follows:

- inputs shall be opto isolated.;
- filters shall be provided for noise rejection;
- output status shall be indicated by an LED;
- all outputs shall be fuse protected and have fuse failure indication the fuses may be mounted externally from the output module;
- all the modules shall be of addressable type.
- Ethernet I/O modules shall be connected to the PLC by on board Ethernet 10/100 BaseT connection port. Ethernet I/O modules shall support multiple communications including TCP/IP and Modbus ASCII and RTU allowing connection to any device supporting these protocols over standard Ethernet backplane.

h) Analogue Input Modules

They shall consist of an input isolation unit, signal conditioning unit and an analogue to digital converter (ADC). In addition, the following features shall be provided.

- cross talk attenuation
- provision for monitoring of the ADC for overflow detection
- gain amplifier with high common mode rejection ratio
- accuracy for analogue signals shall be 0.5%

i) Digital Input Modules

The following design features shall be provided.

- contact bounce protection;
- choice of type of contacts.

j) Digital Output Modules

The digital output module shall provide contact closure output by driving relays. The features to be provided are as follows:

- contact bounce protection shall be provided
- relay output shall be provided to operate pump motors and motorised valve actuators
- fail safe position in case of output module failure and fault indication

PLC's provided under this specification shall be capable of performing the necessary logic to control the system as previously defined. These capabilities shall include, but not be limited to the following:

1) Discrete input/output	10) Latch/unlatch relays
2) Analog input	11) Counters
3) Analog output	12) Comparators
4) Timers	13) Ladder logic
5) Pump Controller	14) Flow Totalization/ Integration
6) Pump Alternation	15) Intrusion Detection
7) Mathematical Function Blocks	16) Time of Day Control w/Lockout
8) Stage Blocks	17) Ramp Blocks
9) Trending	18) Data Logging

A. PLC Programming

PLC programming shall be carried using functional block diagrams (FBD). The logic shall be prepared using proprietary programming software and shall be comprehensively annotated with subroutine and rung comments to assist further development and maintenance.

The system shall support a simple programming of the application software comply with IEC 61131-3.

The system shall support a structured, modular programming. At least the following standard operations shall be applicable:

1) Logic functions (such as AND/OR/AND NOT etc.);
2) Timer functions (externally adjustable);
3) Counter functions;
4) Skip functions;
5) Comparison functions;
6) Limit value functions;
7) Arithmetic functions;
8) Physical unit functions;
9) Closed-loop functions such as P/PI/PID/etc.

The Contractor shall submit the logic diagrams for review. The Contractor shall include the as-built logic in the final submission.

B. Programming Unit

The programming unit –Industrial grade laptop (16" screen) shall be of the portable type, designed to be used during commissioning on site. A functional keyboard which supports different type of programming methods shall be included, as well as a LCD display.

On a minimum, the following functions shall be included:

i) On-line programming
ii) Off-line programming
iii) Flexible corrections during input

iv) Full screen editing functions
v) Absolute and symbolic programming
vi) Input of comments and title blocks for complete documentation
vii) Complete application software documentation functions. Printouts of application
viii) Software logic functions shall preferably be in Ladder logic diagrams.
ix) Load and transfer functions

The portable programming unit with minimum 16" screen shall be provided complete with proprietary PLC programming and SCADA software complete with plant mimics and documentation software. Communications cables required to interact with the PLC, (E.g.: Modbus Cable) would be supplied by the Contractor.

The software shall provide facilities for:

- carrying out program revision management;
- insertion of comprehensive program subroutine and rung comments;
- search and find and search and replace 'contacts' and 'coils';
- simulation functions and testing of the program by changing the status of contacts and monitoring the outputs;
- preparation of coil and contact list and their locations and memory maps;
- make system backup copies while the system is online;
- upload and down load programs to the PLC on line;
- Carry out on line maintenance and fault finding on the PLC.

Feature	**Technical Specifications**
Operating System	Latest Windows Operating System (Compatible for PLC software)
Processor	Intel I5-13th Generation
Processor Speed	Upto 4.6 Ghz
Graphics	NVIDIA Quadro RTX A500 4 GB
Memory	32 GB RAM
Hard Drive	1 TB SSD
Display	16'' FHD

C. HMI

The HMI shall be with 15" color screen and with touch screen capabilities with IP-65 rating.

All Remote I/O panels which are connected to the main plant PLC based SCADA system shall be equipped with a 15"minimum, panel HMI .The HMI graphic shall be suitable for day to day operation by non-computer literate personnel in the monitoring and operation of the treatment works.

The HMI shall provide efficient and safe operation of the process plant by detecting alarm and error conditions, alerting the operator to these conditions both visually and audibly, monitoring all important system parameters and providing facilities for plant optimization. The system will allow operators, technicians and Employer Representatives to issue commands to change system parameters, start and stop equipment, provide configuration tools and operate diagnostic facilities.

The System shall perform all the necessary functions for the optimum monitoring, control and operation of the particular system. HMI unit along with software packages shall be considered, and also those software packages and Hardware shall be compatible with TCP / IP protocols as well as OPC communication (Open Standard Communication).

The Human Machine Interface (HMI) shall offer a high resolution and high brightness touch screen and include support for processors for up to 1GHz pulse wave,. The HMI shall be rugged and CE-certified and shall offer protection from vibration and changing ambient temperatures, shall include Built-in stereo speakers to increase utility and provide operational flexibility to the plant operators.

D. Ethernet Switches

The Contractor shall only provide managed industrial grade managed Ethernet switches under this contract. All switches shall be in redundant configuration.

13.28 Minimum I/O Requirements for Auto mode Control operation of the Plant:

On a minimum, the control design shall incorporate the I/O requirements which are indicated in the table. All process & Instrumentation Diagrams (P&ID) shall incorporate & depict the minimum I/O requirements as indicated in the table below.

Design shall include complete auto mode of operation of the entire WwTP and associated plant/stations with all necessary interlocks and safety mechanisms.

Minimum I/O to be provided under this contract for the Control system and to be included in the system design is as under:

Sl No	TYPE	MINIMUM I/O'S TO BE CONSIDERED AND INCLUDED
1.	Pump, Motor	Start, Stop, speed command, Available, Auto, Off, Manual, Run, Emergency Stop, Fault, Speed ref
2.	Valve	Available, Auto, Off, Manual, Open, Close, Travelling Indication, Fault
3.	Drives	Available, Start, Stop, Auto, Off, Manual, Run, Emergency Stop, Fault
4.	Blower	Available, Start, Stop, Auto, Off, Manual, Run, Emergency Stop, Fault
5.	Level Indicator	HH, H, L, LL, Analog value,
6.	Level Switch	HH, H, L, LL,
7.	Analytical Instruments	Analog Value,
8.	Pressure Indicators (Gauges)	Shall be provided for individual delivery lines of Pumps cum Blowers
9.	Pressure transmitters	Shall be provided at common discharge of Pumps (including Dosing Pumps) & Blowers: Analog Value.
10.	Flow Indicator/Transmitters	Please refer Part-5 for list of required flow meters: Analog Value.
11.	Temperature Transmitters	Process Air Blowers common header line, Anaerobic Digestors (Top, Middle & Bottom), Hot Water Boiler, Heat Exchanger (Inlet & outlet), Biogas Engine and as required wherever applicable as per process

		requirement.
12.	Temperature Gauges	Process Air Blowers common header line, Anaerobic Digestors (Top, Middle & Bottom), Hot Water Boiler, Heat Exchanger (Inlet & outlet), Biogas Engine and as required wherever applicable as per process requirement.

13.29 Typical Drive Control Philosophy to be provided on a minimum shall be as follows:

SL. NO.	DESCRIPTION	Type of I/O	No of I/O
1.	**PLC INTERFACE FOR UNIDIRECTIONAL HT, LT & Transformers BREAKER CONTROL DRIVE (Signal Exchange has been envisaged between PLC and switchgear)**		
a.	OPEN Command	DO	1
b.	CLOSE Command	DO	1
c.	OPEN Feedback	DI	1
d.	CLOSE Feedback	DI	1
e.	Auto, Off, Manual	DI	2
f.	Swgr. Disturbance (Earth fault/ Overload/ Under voltage/ Transformer relay operated/ control supply fail/Master Trip)	DI	1
g.	Emergency stop PB (Operated feedback)	DI	1
h.	PCC Switchgear Available (breaker in service position, switchgear in remote & breaker spring charged)	DI	1
2.	**PLC INTERFACE FOR UNIDIRECTIONAL LT DRIVE (Signal Exchange has been envisaged between PLC and PCC/MCC)**		
a.	Start Command	DO	1
b.	Stop Command	DO	1
c.	ON Feedback	DI	1
d.	OFF Feedback	DI	1
e.	Auto, Off, Manual	DI	2
f.	MCC Disturbance (Overload relay operated/ control supply fail	DI	1
g.	Emergency LPBS stop	DI	1
h.	Water Intrusion feedback (for submersible drives)	DI	1
i.	VFD Speed Feedback	AI	1
j.	VFD Speed Command	AO	1
k.	Electrical Trip (Motor Protection Relay)	DI	1
l.	Pump bearing temperature measurement	AI	2
m.	Motor Bearing temperature measurement	AI	2
n.	Motor Winding temperature measurement	AI	3
o.	VFD Speed Feedback	AI	1
p.	VFD Speed Command	AO	1
3.	**PLC INTERFACE FOR BIDIRECTIONAL LT DRIVE- For Integral starters**		

SL. NO.	DESCRIPTION	Type of I/O	No of I/O
	(Signal Exchange has been envisaged between Actuator and PLC.)		
a.	Open Command	DO	1
b.	Close Command	DO	1
c.	Integral starters Fault	DI	1
d.	Open limit switch feedback	DI	1
e.	Close limit switch feedback	DI	1
f.	Auto, Off, Manual	DI	2
g.	Available	DI	1
h.	Position Transmitter (For inching type Drive / Control Valves)	AI	1
i.	Command (Control Valves)	AO	1
j.	Emergency LPBS stop)	DI	1
4.	**PLC INTERFACE FOR BIDIRECTIONAL LT DRIVE-For Non-Integral starters (Signal Exchange has been envisaged between Actuator and PLC.)**		
a.	Open Command	DO	1
b.	Close Command	DO	1
c.	Auto, Off, Manual	DI	2
d.	Swgr/MCC Disturbance (Overload relay operated/ control supply fail/	DI	1
e.	Emergency LPBS stop)	DI	1
f.	Available	DI	1
g.	Switchgear/MCC Available (switchgear/MCC in remote)	DI	1
h.	Open limit switch feedback	DI	1
i.	Close limit switch feedback	DI	1
j.	Position Transmitter (For inching type Drive)	AI	1
k.	Command (Control Valves)	AO	1
5.	**PLC INTERFACE FOR SOLENOID DRIVE (Single coil)**		
a.	Energise or Deenergise	DO	1
6.	**PLC INTERFACE FOR SOLENOID DRIVE (Double coil)**		
a.	Energise or Deenergise	DO	1
7.	**PLC INTERFACE FOR PNEUMATIC DRIVE**		
a.	Command to I/P converter	AO	1
b.	Position Transmitter	AI	1
c.	Open limit switch feedback	DI	1
d.	Close limit switch feedback	DI	1
e.	Command to Solenoid valve (Wherever applicable)	DO	1

13.30 Closed Circuit Television (CCTV) System

Design, supply, install, test and commission CCTV system including its interface with main plant SCADA system; The Contractor shall install the CCTV cameras at all process locations. During construction ,the CCTV system shall be installed at all process locations/construction points Additionally, Contractor shall ensure that the CCTV feed is web based and can be accessed through standard web

browsers. High speed broadband internet connection shall be utilized on site to relay the CCTV feeds as required for monitoring from Shimsha Bhavan.

The Contractor shall be responsible for the detailed design, supply, installation, testing and commissioning and training of Employer's staff of Closed Circuit Television (CCTV) system to be installed in the SCADA control room & at all process locations in the plant on a minimum covering all process units ,entrance to the WwTP and ISPS, along the boundary wall, storage facilities and other areas of the WwTP and ISPS. The CCTV system shall be designed to have complete coverage of the plant.

The scope shall include all necessary cabling, indoor & outdoor cameras and lenses, camera housing, TV monitor, control and interface units, coaxial cable transmission, video switching unit, time-lapse video recorders and tapes, junction boxes, power supplies, mounting brackets, etc, as required to provide a cost effective and reliable and fully operational CCTV system complying with the specification and to the approval of the Employer's Representative.

The CCTV system shall incorporate all equipment necessary to enable all areas to be viewed from the CCTV station monitor. The CCTV monitoring system shall be of latest design incorporating all the power and signal wiring as per manufacturer's standard. The system shall be complete package of one supplier of equipment, fixings, wiring conducting and all items necessary for a complete installation.

Materials

Cameras

Cameras shall be digital high resolution colour cameras having 1/3 inch CCD 450 TV lines with lens and an interlace of 2:1 in the scanning system of high excellent quality and performance utilising latest digital technology of super colour reproduction with low light high sensitivity down to 5 lux with electronic shutter speeds 1/50 to 1/30000 seconds .

Cameras shall be provided with a 14mm automatic lens with/without "drive" (amplifier) for 1/2" sensors, F1.4 CS mount, 22° angle shot and a composite video output at 75 ohms lines and the useful illumination range shall be 1.5 lux. The camera lens shall be of the auto iris zoom type with spot filter providing automatic control throughout the iris range from fully open F1.4, the lens shall incorporate a shutdown mechanism to protect the camera from high light level during periods of not in use. A neutral density filter designed to maintain image detail and contrast shall be incorporated in the lens. The output signal shall be of PAL. The Camera shall be suitable for the specified environmental conditions.

The camera shall be provided complete with all accessories required. The camera shall have the following features.

1. Program modes 1.5, 3, 6 minutes;
2. Variable scan speed between 1.40° per second;
3. Programmable limit stops for auto/random/frame scan modes;
4. Series protocols BS-422 'P' series and 'D' series;
5. Built-in menu system;
6. Pan movement – 360° continuous pan rotation;
7. Vertical tilt - Unobstructed +2 to +92°;
8. Variable pan/tilt speed controller;
9. Preset speeds:
   Pan – 250°/sec
   Tilt – 100°/sec
10. Electrical input – 24V AC.

Monitor

The monitor shall be of high resolution type suitable for CCTV system and shall comply with the following:

1. LED Screen: 32";
2. Power Supply: 240V, 50Hz;
3. Resolution : 420 lines;
4. Bandwidth : 5 MHz (±3dB);
5. Video Input : 1 Vpp 75ohm;
6. Input/Output: BNC Video connector;
7. Front Controls: Power ON/OFF;
8. Brightness Control;
9. Contrast Control;
10. Colour Control.

Matrix Switcher

The matrix switcher shall be micro-processor based and provide switching and control for 16 video inputs and up to 4 monitor outputs from any one keyboard. The unit shall be remotely operated by desk-top key boards or external computer systems. The switcher shall have on-screen menu programming. The switcher shall support two system macros or salvo sequences to allow quick call-up of up to four cameras to four monitors simultaneously.

The salient features of the switcher shall be as follows:

1. 16 volts inputs; 2 or 4 video outputs;
2. 20-character camera title;
3. Time (24-hour or AM/PM formats), Date (4 formats);
4. Video inputs individually detectable for terminating or looping;
5. Individual monitor sequential switching with preset cell;
6. Compatible with RS 422 protocol;
7. Camera control selection;
8. Full duplex RS485 keyboard communications;
9. Selectable data port – RS 232/RS 422/RS 425;
10. Password protected menu programming;
11. User partitioning to prevent un authorised viewing.

Receiver

The receiver shall operate on the principle of transmitting of transferring control information and video data on the same line. Standard control features shall include pan/tilt control, camera power, zoom lens control (zoom, iris, and focus with adjustable speed).The receiver shall be compatible with control systems utilizing standard 15-bit command protocols. Auto random scan capability or preset positioning shall be possible.

The test local control module shall allow on-site testing of system functions.

The salient features of the receiver shall be as follows:

1. Input power – 240V 50Hz AC;
2. Control method – 15 pulse train superimposed on the video signal;
3. Pulse amplitude – approximately 1 Vp-p added to video signal, 333kHz nominal;
4. Connectors – two BNC connector for video input and output one 37pin
   Amp CPC for control output;
5. Input video level – 1 Vp-p nominal, 2 Vp-p maximum;

6. System band width – Less that 2dB down at 10 MHz;
7. Fuse protection – 3 AG type;
8. Power chord – 3 wire grounded 18 AWG;
9. Operating distance – RG 11 at 1828 m;
10. Ambient temperature –20 to + 60°C.

The receiver shall be UL listed and shall comply with NEMA 4X and be CE compliant.

Amplifier

The video amplifier shall be of solid state circuitry and is meant for post equalization application only. The amplifier shall provide effective means of maintaining CCTV picture quality with RG11 coaxial cable.

The general construction of the amplifier shall consist of cover, chassis and panel.

The salient features of amplifier shall be as follows:

1. Input voltage – 240V AC;
2. Power transformer – 1.5VA (1.25 AMP) at 12 ±15% volts, 50Hz;
3. Input – Single BNC internally terminate in 75ohms;
4. Outputs – Single BNC source terminated;
5. Gain – Adjustable form 1 to 8dB;
6. Frequency response – Adjustable form flat (±1dB) at 12 MHz, greater than 18dB of boost at 12 MHz;
7. Output dynamic range – Up to 2 volts p-p at 50% APL;
   Up to 1.5 volts p-p at 90% APL.
8. Cable length – RG 11 – 1828.8M;
9. Ambient temperature – 0° to 48.89°C at 0 - 90% RH.

The amplifier shall be UL listed to standard 2044 and comply with NEMA 1 and be CE compliant.

Time Lapse Video Cassette Recorder or Disk recorder

The time-lapse VCR/disk recorder shall be designed to suit multiple use. The recording capability shall enable continuous coverage over a long period of time with minimum tape changes.

Recording mode shall include standard VHS2 and 6-hour real time modes in addition to high density 18-hour linear real time recording. SP and EP recording modes shall make increase field recoding rate using standard high quality T120 VHS tapes.

The programming menu shall appear on the monitor output to provide easy setup of any programme feature. A lock mode shall disable all front panel controls presenting all changes to the unit's programming or operation. Playback features shall include speed search and reverse play back. Automatic alarm search feature shall allow the operator to go to a specific alarm index.

The salient features of disk recorder shall be as follows:

1. Standard VHS 2/6 hour recording mode;
2. 18/24/218/72/96/120/168 hour VHS compatible time-lapse modes;
3. Internal / short recording mode;
4. 24 hours real time recording mode;
5. High density record mode – triple speed time lapse recording;
6. Audio recording up to 24 hours;
7. Alarm index search;
8. Jog/shuttle for easy forward and reverse field playback and search;
9. On-screen menu programming;
10. Eight daily/weekly reading schedules.

CCTV Integration

A Close Circuit Television Camera's (CCTV) based on IP standard should be amenable to be integrated with the SCADA system. The camera integration feature should be a standard feature of SCADA in following ways -

Web Services

Video Viewer - ActiveX Control

PTZ Control (Pan, Tilt, Zoom) - ActiveX Control

Camera Manager

Add / Edit / Remove cameras in runtime environment

Camera configuration stored in DBF files

Pre-built Displays:

1 Up

2 Up

4 Up

9 Up

Additional features such as pop-up displays for motion/intrusion detection and linking of events with video functions should be made available.

Broadband internet services with high speed connectivity shall be used for data communication from CCTV monitoring locations to the CCTV server. The most suitable package of high speed broadband internet service provided by an Internet Service Provider (ISP) which suits the Client's requirement for high speed real time monitoring thru the CCTV shall be utilized. The Contractor shall enter in to SLA agreement to provide continuous fail safe services as required under this contract.

13.31 Approved Vendor/Manufacturer/Make List-CCTV

The naming of a manufacturer in this specification is not intended to eliminate competition or prohibit qualified manufacturers from offering equipment. Rather, the intent is to establish a standard of excellence for the material used, and to indicate a principle of operation desired.

Description	**Vendor/Manufacturer/Make**
CCTV systems	1. M/S HONEYWELL 2. M/S YOKO INTERNATIONAL 3. M/S AVTEL 4. M/S MOBOTIX 5. M/S JMACS 6. M/S BOSCH

13.32 Approved Vendor/Manufacturer/Make List-Instrumentation

The naming of a manufacturer in this specification is not intended to eliminate competition or prohibit qualified manufacturers from offering equipment. Rather, the intent is to establish a standard of excellence for the material used, and to indicate a principle of operation desired.

i) List of Makes for Instruments:

Sr. No.	**Description**	**Vendor/Manufacturer/Make**
1	LEVEL INDICATOR TRANSMITTER	M/S ABB-GERMANY

Sr. No.	Description	Vendor/Manufacturer/Make
		M/S ENDRESS+HAUSER M/S YOKOGAWA M/S SIEMENS M/S ROYCE INSTRUMENTS M/S HITACHI HIGH-TECH M/s KROHNE M/S VEGA M/S BADGER METER USA
2	FLOW METERS/FLOW INDICATOR/ TRANSMITTER (ELECTROMAGNETIC, THERMAL, ULTRASONIC)	M/S EMERSON-USA M/S YOKOGAWA M/S ENDRESS+HAUSER M/S HITACHI HIGH-TECH M/S AICHI TOKEI DENKI CO LTD M/S ABB-GERMANY M/S KROHNE M/S BADGER METER USA M/S SOMMER AUSTRIA M/S ISCO TELEDYNE
3	LEVEL/FLOAT SWITCHES	M/S ABB-GERMANY M/S ENDRESS+HAUSER, M/S KROHNE GMBH GERMANY M/S P&F GERMANY M/S LEVCON, M/S. PUNE TECHTROL M/S HITACHI HIGH-TECH
4	PRESSURE GAUGES	M/S GENERAL INSTRUMENTS M/S. BAUMER M/S MIGISHITA (JAPAN) M/S NAGANO KEIKI M/S ASAHI M/S WIKA
5	PRESSURE INDICATOR TRANSMITTER & SWITCHES	M/S EMERSON-USA M/S ENDRESS+HAUSER M/S SIEMENS M/S. BAUMER M/S HITACHI HIGH-TECH M/S FUJI ELECTRIC M/S ABB-GERMANY
6	ONLINE RESIDUAL CHLORINE ANALYZER	M/S TETHYS INSTRUMENTS-FRANCE M/S ENDRESS+HAUSER M/S DKK -JAPAN M/S PROCESS INSTRUMENTS –UK M/S YOKOGAWA (JAPAN) M/S HACH-USA M/S ATI UK

Sr. No.	Description	Vendor/Manufacturer/Make
		M/S BADGER METER
7	TEMPERATURE INDICATOR TRANSMITTERS	M/S ENDRESS+HAUSER M/S HAYASHI DENKO (JAPAN) M/S YOKOGAWA (JAPAN) M/S ABB-GERMANY M/S SIEMENS M/S FUJI ELECTRIC
8	ANALYTICAL ONLINE INSTRUMENTS (DO, ORP, pH, TURBIDITY, SLUDGE BLANKET MONITOR)	M/S IN SITU(USA), M/S HACH USA M/S ENDRESS+HAUSER M/S PROCESS INSTRUMENTS- U.K M/S DKK (JAPAN)
9	ONLINE REAL TIME INFLUENT & EFFLUENT MONITORING SYSTEM	M/S HORIBA-FRANCE M/S HACH-USA M/S IN SITU-(USA) M/S AQUALABO-FRANCE M/S BADGERMETER-USA M/S AXIS NANO TECHNOLOGIES M/S XYLEM M/S SCAN AUSTRIA M/S SHIMADZU M/S GE SIEVERS M/S E&H
10	AUTO SAMPLERS	M/S HACH-USA M/S TELEDYNE ISCO -USA M/S WATERSAM-GERMANY M/S AXIS NONO TECHNOLOGIES M/S MAXX-GERMANY M/S YSI M/S XYLEM
11	LABORATORY EQUIPMENT	M/S HACH-USA M/S AXIS NANO TECHNOLOGIES M/S LAMOTTE M/S PERKIN ELMER M/S SHIMADZU (JAPAN) M/S SAVANT M/S XYLEM MSIW / WTW M/S ACZET M/S FISCHER SCIENTIFIC M/S SIGMA ELDRICH
12	UN-INTERRUPTIBLE POWER SUPPLY SYSTEMS	M/S NIPPON KEIDENKI WORKS M/S FUJI ELECTRIC M/S HITACHI M/S MEIDENSHA CORPORATION M/S APC

Sr. No.	Description	Vendor/Manufacturer/Make
		M/S FURUKAWA BATTERY M/s DELTA
13	BATTERIES	M/S SANKEN ELECTRIC M/S AMCO M/S EXIDE M/S SEC M/S FURUKAWA BATTERY
14	PANELS	M/S RITTAL M/S ELDON M/S CEPL M/S HOFFMAN M/S BCH
15	CABLES	M/S UNIVERSAL CABLES M/S HAVELL'S M/S CCI M/S FINOLEX M/S NICCO M/S DELTON CABLES LIMITED M/S POLYCAB M/S CORDS

Note-1: In order to achieve standardization for appearance, operation, maintenance, spare parts and manufacturer's service, like items of equipment provided hereunder shall be the end products of one (1) manufacturer.

Note-2: All products shall be completely manufactured in the country of Origin as indicated. Assembled products shall not be accepted.

Note-3: In the event that the Contractor wishes to propose alternate makes for the equipment mentioned above, he shall submit the following during detailed engineering:

1) Submit regret letters from the approved vendors that the equipment is not available
2) Demonstrate that the proposed makes are "equivalent " to the approved makes. The Contractor shall ensure that alternate makes proposed, shall comply completely to the tender specifications, before the same is submitted for approval.
3) Submit ISO certificates for the OEM.
4) Submit quality certificates that the equipment adheres to, as required under this contract.
5) Submit product brochures for the proposed equipment.
6) Manufacturer involved in manufacture of specified equipment for at least 10 years before bid date
7) End user performance certificates for minimum 10 successful individual installations of similar size as per this contract with the proposed equipment and model no, commissioned & satisfactorily operating for at least 5 years before bid date.
8) Manufacturer to provide full contact information for each reference as part of technical bid.

13.33 Approved Vendor/Manufacturer/Make List-Automation

The naming of a manufacturer in this specification is not intended to eliminate competition or prohibit qualified manufacturers from offering equipment. Rather, the intent is to establish a standard of excellence for the material used, and to indicate a principle of operation desired.

Sr. No.	Description	Manufactures/Makes		
1	WORKSTATIONS, SERVERS, LAPTOP NOTEBOOK	M/S-DELL M/S-HP M/S-LENOVO M/S-IBM		
2	PROGRAMMABLE LOGIC CONTROLLERS & IO MODULES	**Make**	**CPU Series**	**IO Series**
		SCHNEIDER ELECTRIC	M580 SERIES	X80
		SIEMENS	S7- 414H	ET-200 SP
		ALLEN BRADLEY	CONTROL LOGIX L8 SERIES	POINT
		MITSUBISHI ELECTRIC	R16P	M SERIES
		OMRON	CS1D,CJ,SYSMAC, NJ, NX,CP2E SERIES	NX IO Family
3	SCADA PROGRAMMING SOFTWARE	AVEVA PLANT SCADA, SIMATIC WIN CC EXPLOREE, FACTORY TALK, MC WORKS, CX-SUPERVISOR,MOVICON, SYSMAC STUDIO Note: All software's shall be of the latest series version and shall include both runtime and developer versions.		
4	HISTORIAN SOFTWARE	WONDERWARE HISTORIAN MC HISTORIAN SIMATIC PROCESS HISTORIA FACTORY TALK HISTORIAN SE CX SUPERVISOR, MOVICON		
5	REMOTE TERMINAL UNIT	M/S-SIEMENS, M/S-ABB, M/S- MITSUBISHI, M/S-OMRON, M/S-SCHNEIDER ELECTRIC, M/S TOSHIBA, M/S ROBUSTEL		
6	DC POWER SUPPLY	M/S-APLAB, M/S-WAGO, M/S-PHOENIX CONTACT, M/S-MEAN WELL, M/S-WEIDMULLER, M/S-OMRON. M/S-SHAVISION		
7	PANEL HMI	M/S SCHNEIDER-MEGLIS, M/S-ADVANTECH, M/S-MITSUBISHI, M/S-PANASONIC, M/S-SIEMENS, M/S- M/S-ABB, M/S-OMRON.M/S-TOSHIBA		
8	LED MONITORS/DISPLAYS/VDU	M/S-SAMSUNG, M/S-LG, M/S- SONY, M/S-DELL,M/S-BENQ,M/S-HP		

9	PRINTERS	M/S- CANON, M/S- FUJI, M/S- XEROX, M/S-EPSON, M/S-RICOH
10	CONTROL ROOM CONSOLES& FURNITURE	M/S PYROTECH WORKSPACE, M/S EVANS,M/S QUEST, M/S WINSTED, M/S ADARSHA CONTROLS
11	PLC / RIO PANEL	M/S RITTAL M/S GABIONICS M/S HOFFMAN M/S SCHNEDER M/S Nvent M/S BCH M/S ELDON

Note-1: In order to achieve standardization for appearance, operation, maintenance, spare parts and manufacturer's service, like items of equipment provided hereunder shall be the end products of one (1) manufacturer.

Note-2: All products shall be completely manufactured in the country of Origin as indicated. Assembled products shall not be accepted.

Note-3: In the event that the Contractor wishes to propose alternate makes for the equipment mentioned above, he shall submit the following during detailed engineering:

1) Submit regret letters from the vendors indicated that the equipment is not available
2) Demonstrate that the proposed makes are "equivalent " to the approved makes or superior. The Contractor shall ensure that alternate makes proposed, shall comply completely to the tender specifications, before the same is submitted for approval.
3) Submit ISO certificates for the OEM.
4) Submit quality certificates that the equipment adheres to, as required under this contract.
5) Submit product brochures for the proposed equipment.
6) Manufacturer involved in manufacture of specified equipment for at least 10 years before bid date
7) End user performance certificates for minimum 10 successful individual installations of similar size as per this contract with the proposed equipment and model no, commissioned & satisfactorily operating for at least 5 years before bid date.
8) Manufacturer to provide full contact information for each reference as part of technical bid.

13.34 Supervisory Control and Data Acquisition System (SCADA)

The SCADA shall be a fully integrated microprocessor based control and data acquisition system which will monitor, control, display, record, archive plant and historical data and trend all assigned plant inputs and outputs. The SCADA shall be a fully dual redundant microprocessor based computer system such that reliable and fully automatic plant control can be achieved.

The main process monitoring and control shall be by means of VDU based process operator workstations that shall be located in the central control room.

SCADA system would be dual redundant server system. The system shall be designed and implemented such that the failure of a central processor or HMI console does not inhibit continuous automatic control of the plant.

Failure of a single outstation or communications to that outstation shall not effect control or operation of any other outstation, unless the failed outstation provides essential data to another outstation, in which case the non-failed outstations shall revert to a fail-safe mode.

An alarm shall be generated whenever a communications system failure occurs.

The SCADA system shall provide a complete monitoring & control of the entire WwTP and ISPS facility via the redundant PLC based control system and RIO system.

WwTP SCADA system shall comprise the following on a minimum:

a) Dual redundant SCADA servers with SCADA server (includes web server type) software with minimum ten thousand tags life time licensed without any time bound.
b) Historian server system inclusive of Historian software i.e. thousand tags lifetime licensed without any time bound.
c) Engineering & Operator work stations loaded with SCADA software and with latest Windows Operating system, minimum 2TB storage, latest processor, etc.
d) CCTV Monitoring station loaded with required software and with latest Windows Operating system, minimum 1TB storage, latest processor, etc
e) LIMS system and its integration with SCADA historian system:
f) SCREENS, 55" in array of 2X3 (total 6 monitors) networked with SCADA servers to display the process screens, alarms & reports, CCTV Feeds, with all required hardware & software accessories
g) Redundant industrial managed Ethernet switches
h) Licensed MS Office & Antivirus software to be loaded on each system
i) Industrial grade control system console to house the entire PLC based SCADA system and other equipment as indicated in the system configuration diagram.
j) All required software and hardware to implement the system as indicated in the specifications and system configuration drawings.
k) WwTP Bulk transfer of data (complete plant operational data inclusive of lab data and LIMS data and ISPS Data) to be transmitted to MIS-2 center at Shimsha Bhavan, through redundant GPRS communication system.
l) Monitoring of ISPS in real time and receiving of ISPS data from each ISPS control system and displaying the ISPS complete plant mimics on the WwTP SCADA screen.
m) Control of ISPS control system from the WwTP control system as and when required. The feature shall be demonstrated during control system FAT.

The SCADA system shall follow the International Standards Organization (ISO), Open Systems Interconnect (OSI), reference model guidelines. All central system hardware and software devices shall be interconnected using a bus topology data highway. The communications protocol used shall generally meet the requirements of the ISO.
The system shall provide efficient and safe operation of the complete plant by detecting alarm and error conditions, alerting the operator to these conditions both visually and audibly, monitoring all system parameters and providing complete facilities for plant operation and optimization.

The System shall perform all the necessary functions for the optimum monitoring, control and operation of the entire system. For each abnormal condition, Plant failure, Plant unavailable or failure to respond to a command within a given period, the system shall provide the appropriate alarm.

Printed and archived alarms shall be time and date stamped for occurrence and acceptance. Alarms, logs and reports shall be output to separate printers. Alarms shall be in red. The ability to generate alarms within the system software based upon digital and / or analogue events and set points shall be provided.

An alarm horn with silence button shall be provided to alert the operator of an alarm condition. Specific alarm, monitoring and control input / output requirements shall be determined from the particular control specifications and the Project Drawings.

13.35 SCADA Software Functions

General:

1) The Contractor shall be responsible for supplying complete software packages to enable the equipment to operate as stated in this specification. Provision must be made for the adding of further software tasks as and when required. All software functions shall be user friendly, with instruction and messages to aid the operator. The Contractor shall make available all standard software functions, even if not specifically detailed in the specification.
2) The computers shall utilize a real time multi-tasking and networked operating system with a proven track record in real time control applications.
3) The Operating System shall be latest Windows operating system, loaded with MS-Office latest licensed version suitable for interconnection with external networks in a Wide Area Network (WAN) configuration, where specified.
4) The Application Software shall provide communication with other industrial standard open networks. The Software shall support Object Linked Embedding for Process Control (OPC).OPC should be a in-built feature of the software.
5) The System shall support a fully distributed 64 bit Client/Server architecture. The System shall include Visual Basic for Applications (VBA) as a built-in programming language. Facility shall be available for building custom objects using VBA. Object oriented graphics and tools to easily build reusable control strategies. ODBC Application Program Interface (API) capable of collecting and writing secure real-time electronic records to one or more relational database.
6) The software shall support OPC standards as both a client and a server for fast and reliable communications with a wide variety of hardware devices. Provide Active-X controls with selection of third-party Active-X controls for ready-made solutions without VBA programming. The SCADA software shall use SQL server as the integral database.
7) A standard software package, such as Crystal Report shall be provided to facilitate generation of free format, intuitive and presentation quality reports.
8) The engineering Workstation shall be provided with simulation tools to support off-line testing of the control logics.
9) The Server shall provide the master clock for the SCADA time synchronization.
10) SCADA software design shall include de-activation of CTRL+ALT_DEL windows feature.
11) The system software shall be from the SCADA manufacturer as indicated in the approved vendor list elsewhere in this specification.. Third party software is not acceptable. It is a requirement that the system be supported by on line configuration and editing of all VDU mimic displays and database and to create new displays and additional database.
12) Operational mimics and other graphics shall be presented in an industry standard graphical user interface (GUI) format. A minimum of two active windows shall be displayable concurrently and not more than three windows. Both text and graphics shall resize automatically to accommodate changes made to the size of a window. The system shall be designed to minimize the operator's use of the keyboard. All major functions shall be accessible on-screen through use of the mouse or track ball.
13) Operator system entry, for each area will be password coded with different levels of entry depending on the level of authority of the operator. Development and systems level entry passwords will be

provided for engineering workstations. Each action taken by any operator at any level of entry, or at any operator terminal, shall be log file recorded and time and date stamped. Log in and out time and dates will be printed on the control room event logging printer.

14) Right click menu options on SCADA software shall be designed to be disabled as required.

15) All requests and commands shall be via icons, whether menu linked or linked to equipment control actions. A permanent dynamic alarm banner shall be displayed at the bottom or top of each operator screen. Each control action will be routed through a series of confirmation routines.

16) The reports shall be available for printing in graph or tabular format. Dynamic trend displays shall also be available for all analogue flow, level and pressure values. Custom, as well as preconfigured reports and trends shall be available to a higher level of entry. A colour, A4/A3 size, screen dump printer shall be provided for graph and trend prints.

17) An operator help utility shall be provided, offering help linked to the particular action being carried out by the operator at that time. At least one help screen per screen page shall be available. This facility shall be preconfigured with an option for updating by operators, via a password entry.

18) The Application Server software shall be configurable to provide for the monitoring and control of all points, loops, and systems through graphic display screens and hard copy reports. These shall include:

- Parameter Displays for signal control
- Control Loop Status Displays
- Real Time and Historical Data Trend Displays
- Event Displays and Log Reports
- Alarm Displays and Log Reports
- Equipment Diagnostic Displays and Reports.

19) The system shall provide on-line diagnostics that display the current status and operation of the local area network and its nodes. The diagnostic display shall include the LAN adapter status for the machine showing the display, as well as the current number of messages, errors and retries.

20) The system shall conform to and take advantage of industry standards. These shall include, but not be limited to:

- ODBC
- OLE
- ActiveX
- COM/DCOM
- DDE and Advance DDE
- C programming language
- Visual Basic
- Microsoft Windows XP or the most current Operating System
- TCP/IP
- OPC
- XML

21) Display Facilities and screen/mimic refresh: The displays shall be user configurable, with the user being able to construct any desired symbol for display. Any display shall appear (excluding historical recall) within 1 seconds to 2 seconds of selection and the displayed data shall be updated from the database .Alarms shall typically appear within 3 seconds to 5 seconds of occurrence and within 1 second of being received into the central system database. Plant mimics shall display dynamic color details of flow rates and pressures, pump status, well levels, alarms, electrical power supplies and other general equipment status conditions. The plants mimics shall include animation to depict plant process operation, pump running station, media flow within the plant, levels in the tank, etc. The animation shall be designed such that the screen refresh rate shall not effected. The SCADA servers and workstations (engineering & operator) shall be suitably chosen to meet this requirement.

22) The Contractor shall configure all display pages as fully as possible. However, facility must be incorporated to permit easy construction and modification of the display pages, by using a standard library of shapes and symbols. The library shall be added to and modified by the user as required. The configuration shall be object orientated for ease of use.
23) The initial application software shall provide for the display pages listed below and any pages necessary for the system to function as a complete entity.
a) Mimic displays
b) Graphic displays.
c) Trend displays.
d) Alarm summary tables with date and time.
e) Event logs of past 72 hours with date and time.
f) Tabular display of data.
g) Inset windows showing an analogue trends may be mixed with mimic displays. In such a display the main mimic and inset trend shall all be live with automatic display updates.
h) Indexing of information and menus shall be presented in the form of active windows on the screen, while the mimics etc. are still available for view.
i) No display or function shall effect the logging/monitoring of data. It shall be possible for the master station terminal and auxiliary terminals to perform simultaneously, different tasks within the display.

Monitoring and Alarms

1) The operator shall be able to monitor all of the information at the workstation. He shall be able to view active equipment information by use of graphical and tabular displays.
2) In the event of an equipment alarm, the following shall occur at the master station:
a) Alarm message displayed in the alarm message area of the screen.
b) The audible alarm shall sound.
c) The appropriate Section of the display page shall change color and flash.
d) A full message shall be written on the alarm page.
e) The full alarm message shall be printed on the alarm printer.
f) The full alarm message shall be recorded, stored on disk and automatically archived.
3) The operator should be able to acknowledge the alarm by pressing an accept alarm key or icon. This action shall stop flashing of all associated alarm messages and displays. However the display shall remain in the alarm state fixed color to indicate an accepted alarm. When all outstanding alarms have been acknowledged the audible alarm shall be silenced.
4) Once the alarm has cleared, the messages and displays shall return to normal. The alarm message shall stay recorded on the event/alarm log and an alarm cleared message shall also be recorded.
5) If the alarm clears before being acknowledged the sequence of events shall continue as above except the message shall change to indicate a cleared alarm.
6) An audible alarm silence function shall be provided to enable an operator to silence the audible alarm without acknowledging all alarms. On occurrence of any subsequent alarm, the audible alarm shall sound.
7) Each signal within the configured system shall be capable of being assigned an alarm based on the following:
a) Four levels per analogue (Lo Lo, Hi Hi, Lo and Hi).
b) Rate of change.
c) Deviation from set point or other control parameter.
8) Alarms shall be time tagged to 1 second resolution at the I/O's.
9) A minimum of four alarm priorities shall be provided so that those requiring immediate attention may be separated from alarms of lower priority. An audible alarm shall sound for alarms requiring operator action.
10) Typical alarm assignments are as follows:

a) critical alarm	-	an alarm that requires immediate operator action
b) non critical alarm	-	an alarm that requires operator action but not necessarily immediate action
c) operator guide alarm	-	an alarm that provides information to the operator
d) event	-	a low priority condition which is recorded.

Data Archiving

Continuous process (analogue) data, digital event states, alarms and operator actions shall be archived to a removable media system. The archive media shall be sized to store logged analogue data, at a maximum sample rate of 15 minutes for a period of three months locally. Data recording shall be on dual media. The archive system shall generate an alarm when a file is 60% full.

Analogues will be stored at a rate selected by the operator in the range 1 second to 1 hour. The operator shall have the facility to select the way in which an analogue is stored.

The system will provide any combination of the following:

- Instantaneous value.
- Average value.
- Maximum value.
- Minimum value.
- Not stored.

Maximum, minimum and average values shall be calculated over a period set by the operator in the range 15 minutes to 24 hours, the default shall be 1 hour.

The logging of new data and reception of alarms must be carried out at the same time as the operator is viewing archived data. Any alarms received must be displayed as an overlay on the visual display unit.

The Contractor shall submit the data archiving policy to be adopted as part of functional design specifications for review and approval. The same shall be demonstrated during the factory acceptance test and site acceptance test.

SCADA Screens/Mimics

The Contractor shall configure all the mimics to provide total detailed coverage of the monitoring and control of equipment as detailed in this specification. It is expected that display modifications will be required in the future and therefore the ability to change the displays without programming skills is essential.

Instrumentation shall be displayed using ISO standard symbols. For mimic configuration, it shall be possible to call up a library of standard symbols representing items (e.g. pumps, valves) and add new symbols to the library. Building mimics shall be simple and be achieved by using a mouse or tracker ball pointing device.

The mimic displays shall consist of the following pages on a minimum but not limited to:

a) A general diagram covering the entire sewage treatment plant any associated systems on a single screen with key data being displayed. The same shall be constituted as plant overview screen. The same shall be programmed with complete animation to depict the normal process operation and process media flow within the treatment system.
b) A general block diagram for each site or area of Site showing the equipment displayed on a series of single screens with key data

c) Mimic of the equipment and instrumentation connected to each IO module displayed on as many screens as necessary.
d) Individual process screens
e) PLC network monitoring screen
f) Communication interface with ISPS control system and other interfaces as required under this contract.
g) Individual vendor packaged PLC monitoring screen
h) Login screens, reports screen, security screen, overall WwTP screen, etc.. Shall be configured.
i) Screens indicating the current status of each equipment, maintenance schedule/status, Run hours, set points for all equipment inclusive of vendor supplied systems
j) Complete operational screens shall be developed for WwTP SCADA for vendor packaged system's, irrespective of the vendor system HMI screen supplied.

The SCADA software shall have the ability to limit the number of displays being opened simultaneously at any given point of time. The software shall be able to display at least three process screens/pop up screens simultaneously and shall be active screens.

Trend Displays

It shall be possible to plot dynamically updated real time data and archived data on a line graph, to represent analogue or digital information. Each graph shall be capable of displaying 8 plots overlaid on a graph of different colors and line texture. Next to the graph, there shall be a key relating each color to its function.

The horizontal axis shall be time based and user selectable in minutes, hours, days, weeks, for example, together with a start time.

The vertical axis shall be scaled as a percentage of range and be displayed in the colour of the selected reading. To avoid cluttering, the vertical axis scale shall be changed by selecting the individual display. The vertical axis shall be automatically scaled for each selected point, between limits entered by the user.

Actual values in engineering units shall be displayed by positioning a cursor at the desired point of the trend graph. The display of the data shall also be available in tabular form.

a) Manual Data Entry:

The system shall be provided with facility for entering data manually via the keyboard. This data will fall into two types:

a) Constants which will be changed infrequently. This data may have time and date associated with it.
b) Maintenance related comments.

b) Manually Corrected Data:

The system shall allow a person with authorized access to correct manually, erroneous data via the keyboard.

Reports

There shall be a real time spreadsheet facility supplied and installed by the Contractor. The users shall be able to transfer data from either the archive system or live data to the spreadsheet.

The user shall be able to produce daily, weekly, monthly and annual reports using any data and a mixture of formats (tables, graphs, summaries, spreadsheets). It shall be possible to generate reports, either automatically at predetermined intervals, or manually on demand by the Operator.

Typical reports on a minimum would be:

- Inlet and treated flow
- Process parameters
- Laboratory analysis and LIMS data shall be transferred to centralized SCADA system
- Real time data monitoring system report for both inlet & treated flow
- Failures of equipment.
- Analytical instrumentation parameters.
- Wet well and tank levels.
- Discharge pressures.
- Maintenance schedules.
- Power consumption
- Chemical consumption
- Process alarm conditions.
- Status of all vendor control packages

Profiling

From an average, typical or manually entered plot, it shall be possible to set an exception profile whereby readings within an upper and lower level are acceptable. Profiles shall be set graphically.

The user may select for the system to alarm if the reading is outside the profile and highlight such exceptions as part of a report, thereby reducing the need to examine all data, to ensure acceptability. The number of exceptions shall be logged.

Data Manipulation:

It shall be possible to perform simple mathematical functions on any data, including the following functions:

- Addition
- Subtraction
- Multiplication
- Division
- Square root

It shall be possible to log, display or use in a control loop, the resultant data.

Database Query Facilities:

The system shall support the use of database relationships and wild card characters to provide database query facilities. It shall be possible for applications integration to configure queries easily and save them for future use.

Support of Dynamic Data Exchange (DDE) or Structured Query Language (SQL), to permit data exchange between the SCADA and external applications, including spread sheets and databases.

Data shall be presented in tabular format and contain any combination of fields from the main system database. It shall be possible to manipulate the data by specifying search and sort criteria to define data range limits.

Once a query table has been created, it shall be possible to store the configuration and initiate successive look-ups, using a point and shoot technique.

Downloading IO Configuration:
It shall be possible to download configuration to the IO's from the engineering work station and the Portable Programming Unit (Laptop).

Diagnostics:
The system shall have on-line diagnostic facilities to report system faults as they occur. A set of off-line diagnostic routines shall be supplied for more extensive fault diagnosis.

Security Access Levels:
The functions available on the system shall be fully flexible so as to allow users access levels to be customized by the system operator, to suit individual user requirements.

Access to management and engineer levels shall be restricted by user selectable passwords or key switch. The security systems shall be based on a set of privileges, which may be granted or denied to individual uses by the system operator.

Windows functionality of CNTRL+ALT+DEL shall be disabled. On SCADA startup, the system shall load and directly enter in the SCADA welcome home page .The design shall ensure that SCADA software development page shall not be accessed during the startup and only on appropriate login access, the same shall be accessible.

The security/access levels would be divided between Engineers, supervisors and operators.

The system shall be protected from un-authorized changes to the operating system and application programs.

The system shall prevent un-authorized users from re-booting the system or aborting or suspending system-related programs.

The system shall provide three levels of operator access to the system as a minimum, with the first level permitting access to viewing selected plant conditions as described below and the highest level intended for the system manager.

A mechanism shall be provided which prevents users operating at a lower level from accessing functions assigned to a higher level.

The system shall provide a password-protected, user log-on facility for definition of the user access level. Passwords entered during the log-on process shall not be printed or displayed.

The software shall monitor the actions of the user currently logged on at each node and shall log the current user off after a definable extended period of no operator interaction with the system and produce a printed log-off message.

Logging off of the user shall not shut down the system or the SCADA mimic shall not log out. When the operator has logged off, the current SCADA mimic shall be visible for monitoring, but no action shall be possible until the operator has logged in back to the system.

System-generated log messages relating to operator actions, such as alarm acknowledgements or set-point changes, shall include the identification of the current logged-on user.

The Contractor shall provide the following defined user access levels as a minimum and additional levels as instructed by the Employer Representative:

1) Default Level:

The default level shall permit users to view all displays except those specifically assigned to a higher level of access.

2) Operator level:

The operator level shall permit authorized users to access default level activities in addition to the following:

a) Perform control actions;
b) Acknowledge alarms;
c) Enter or modify manually entered data for inclusion into reports.

3) System manager level:

The system manager level shall permit authorised users to access default level and operator level activities in addition to the following:

a) Modify alarm and control set points, dead bands and time delays;
b) Enter or modify historical data;
c) Add, delete or modify individual I/O points or point attributes;
d) Add, delete or modify field device configurations;
e) Create, delete or modify control algorithms;
f) Create, delete or modify graphic displays;
g) Create, delete or modify system reports;
h) Configure trend displays;
i) Access the operating system;
j) Assign access levels and user passwords;
k) Perform any other system maintenance function

Programming:

The method of programming will depend upon the Manufacturers system requirements. However, the following standards shall be followed:

a) All programs shall be written such that they lend themselves easily to alterations and additions.
b) Good programming practice shall be followed using structured programming techniques. All programs shall be tidy in format and logical to follow. Programs should be extensively annotated with comments and be self-documenting.
c) The system shall be supplied with programs that use a high level language.

Programme – Documentation:

As part of the requirements of this specification full documentation is required as below on a minimum:

a) Software user manuals
b) Database point allocation table
c) Complete program listing, flow charts for all sequences and control routines
d) Application software source code(applicable even for packaged control systems)
e) End user license agreements.

13.36 Control Room Furniture:

In addition to the SCADA system equipment, the Contractor shall provide industrial grade system consoles to complement or match both the colour and styling of the equipment. The Control room Furniture shall comply with relevant IEC standards for ergonomic design. System console shall be so designed to house all servers, workstations. Monitors, interface equipment with cables having back entry. Details and design of system consoles shall be submitted to the Engineer for approval. The system console shall be as per the approved vendor list provided elsewhere in this specification.

Typically, The Contractor shall provide five ergonomically designed swivel-type adjustable arm chairs with casters, two lockable cupboard with glass doors , three lockable File cabinets to store reports, storage of operating and maintenance manuals, drawings, logger paper, charts, disks and the like.

13.37 Large Video Screen for SCADA control Room

The LED large screen shall be installed in the SCADA control room. The video wall shall comprise of LED screens (55”each) in a 2x3 display array. The video wall shall provide a professional- grade high-definition image quality, uniform and outstanding brightness, and consistent color expression and accuracy.

The video wall shall be integrated with the SCADA system and the plant CCTV system. The video wall shall be designed and configured to display real time plant mimics, reports, alarms, trends, CCTV feeds, Historian data etc. The video wall shall be configured to display the data on any of the 2x3 LED screens, i.e to take a single input video signal and “split” it across many “screens” as and when required.

The design of the video wall shall allow to show data from various sources. The design shall include required video switcher/controller to select between different sources. The switcher shall be controlled manually or by the SCADA system. This configuration shall allow one moving image to be seen on the wall at one time. If more than one image is required simultaneously, there shall be a choice of:

Dividing the video wall into sections, so that different sections shall show different sources.

Shall utilizes “multi-source” video wall that permits several sources to be used simultaneously (offer additional flexibility to plant operators)

Note: The above functionality shall be demonstrated during the FAT where the equipment has been manufactured.

All required controllers, software and hardware required for achieving this functionality shall be supplied as an integral part of this contract.

The LED video wall shall be with a narrow bezel panel which shall provide professional grade high definition image quality. The video wall shall offer/display Superior luminance uniformity and consistent color across all screens. The screens shall offer on a minimum

Contrast ratio of (4,000:1) for crystal-clear picture quality and vibrant color expression

The video wall shall be designed for 24/7 continuous operation.

The video wall Screens shall provide consistent display clarity and performance in any operational environment with a reinforced weather-resistant panel that deters heat, moisture and dust

Video wall Screen shall be provided with anti-glare polarization which eliminates color changes that might occur due to external light and background reflection.

Feature	**Technical Specifications**
Screen Size	55''
Screen Resolution	1920 x 1080 (16:9)
Haze	25%
Connectivity	Input: HDMI, USB
	Output: DP,DVI, HDMI

13.38 Spares for PLC & SCADA

Contractor shall provide all the services and supplies in accordance with approved procedures for handling of spare parts, which shall include arranging for their proper receipt, stacking and storage.

Spares for Commissioning & Start-up:

Contractor shall identify, define, procure, and supply construction, pre-commissioning, commissioning and start-up spares, special tools and handling gear for each item of equipment.

On a minimum, 1PLC CPU each (Hot standby PLC, standalone PLC used for ISPS), 3 DI Module, 3 DO Module, 3 AI Module, 3 AO Module, 2 Nos of GPRS communication module, 2 no of managed Ethernet switches of each type installed ,30% fuses of each type and size installed shall be supplied.

The same shall be demonstrated during FAT and before commencement of SAT.

Spares list for 1st Year of Operation:

Contractor shall identify, define, procure, and supply construction, pre-commissioning, commissioning and start-up spares, special tools and handling gear for each item of equipment.

These items and quantities should be subject to BWSSB's approval. Upon completion of commissioning, Contractor shall take inventory and ensure that spares for first year of operation as identified and defined are available on site.

Spares List for subsequent 2 Years of Operation:

Contractor shall identify, define and procure subsequent 2 years of operation, spare parts for each item of equipment.

Spares List for subsequent years of operation

Contractor shall identify, define and procure subsequent years of operation, spare parts for each item of equipment as necessary.

Note: Contractor to include Spare list during their bid submission based on the manufacturers recommendation for each item of equipment proposed.

13.39 SCADA Hardware Requirements

The system shall support hardware and software interconnectivity to other networks generally in accordance with the ISO Open System Interconnect 7 layer reference model.

Computers (Workstations):

1) The computer hardware shall be of current technology at the time of installation. Standard server stations, Standard PC technology with modern hardware, latest Windows operating system and data transmission over Industrial Ethernet must be used for the engineering workstations. It must be possible to install more than one engineering station in a system. Minimum 2 Tb capacity systems shall be supplied.

The engineering system must be an open system that, for example, permits the importing of project data from Microsoft Excel, SQL or from CAD/CAE programs. It must be possible to import/export messages to/from Excel and Access for simple processing. Removable memory media must also be provided for each workstation.

It must be possible to back up all database and configuration data both on removable media and on non-removable storage media without the system being offline.
Provision of redundant storage media must be possible for the configuration database. The specs for computer hardware shown are indicative only and minimum requirement to be supplied by the Contractor.

2) All workstations, servers, communications equipment and peripherals shall be from reputed manufacturers, suitable for continuous operation and shall be the most currently available models at the time of construction, subject to approval. Adequate spare capacity shall be included to meet the specified requirements and future expansions. All workstations shall not be loaded more than 60% of their capacity. An alarm shall be generated when this capacity is exceeded.

3) The system shall support hardware and software interconnectivity to external Programmable Logic Controllers (PLC's) over an RS-232/RS-485 serial data link using Profibus / Modbus, Ethernet or similar protocol, subject to the approval of the Employer Representative.

I. SCADA Workstations:

Feature	**Technical Specifications [Industrial Grade Type Workstations]**
Processor	Intel Core I7-13700
Operating System	Latest Windows Server Operating System [Compatible for SCADA software]
RAM Memory	8GB DDR5 RAM
Hard Drive	2 TB HDD
Graphics Card	2GB Grphics card
Ports	USB, HDMI, Display port
Peripheral Options	Keyboard: USB Entry Keyboard
	Mouse: USB Optical scroll Mouse
Monitor	32" LED Display
	1920 x 1080
Software	Latest Antivirus & MS Office

II. HISTORIAN Workstation:

Feature	Technical Specifications **[Industrial Grade Type Workstation]**
Processor	Intel Xeon Silver (8 core, 2.4 GHz, 85W) or higher
Operating System	Latest Microsoft Standard Windows Server-OEM Pack [Compatible for Historian Software]
Form Factor	1U

Memory	2x16GB ECC Memory
Hard Drive	4x1TB SATA 7.2K 3.5
Ports	1Gb 2-Port L
Peripheral Options	Keyboard: USB Keyboard
	Mouse: USB Optical Scroll Mouse
Monitor	32" LED Display
	1920 x 1080
Software	Latest Antivirus & MS Office

Visual Display Unit (VDU)

1) Visual Display Units (VDU's) shall be color monitor monitor screens, capable of displaying information in alphanumeric, bar histogram, graphical and mimic diagram formats. Monitors shall simultaneously display a minimum of 256 colors, non-interlaced, low radiation, flat screen with no discernible flicker. Display of characters shall be legible and stable on a shadow mask tube, having a resolution of not less, so that 1024 by 768 pixels and a refresh rate of not less than 70 Hz. The units shall include all the necessary picture controls to adjust the sharpness, contrast and position of the image. LED VDUs shall be flat screen, minimum requirements: brightness 250 cd/m2, 500:1 contrast ratio, 1600 x 1200 pixels,
2) VDU's shall be 32 inch LED monitor Screens on a minimum.
3) VDU's shall be fitted with a power management system to reduce consumption upon detection of a stand-by signal from the PC.
4) Note: Each SCADA server, engineering and operator workstation, Historian system, CCTV system shall be provided with VDU units as described above.

III. FIRE WALL

Feature	**Technical Specifications**
Interface	4 xGbE copper, 1 x SFP Fiber
Functions Supported	Firewall, Networking VPN

IV. NAS Server (For Historian)

Specification	**Minimum Requirement [Rack mounted Blade Type]**
CPU	Dual-coreIntel®2.4GHzProcessor
Memory	System memory:4GBDDR3RAM
	Memory module pre-installed: 4 GBx1
	Total memory slots:4
	Memory expandable upto:32 GB (8GBx4)
Flash Memory	512MBDOM
Hard Drive	4 x 2 TB SATA6Gb/s
Hard Drive Tray	8xhot-swappable and lockable tray
	2xGigabitRJ-45Ethernetport

LAN Port	(Expandable upto 6x1Gb LAN or 4 x 10 Gb + 2 x 1Gb LAN by installing optional dual-port 10 Gb and 1 Gb network card)
LED Indicators	Status,10GbE, LAN, E-SATA, hard drives
Form Factor	2U, Rackmount
Expansion Slot (PCI-E)	2
Storage Controller	RAID-2

V. Remote telemetry Unit (RTU):

Specification	**Requirement**
Dynamic memory (RAM) (program execution, dynamic variables and file system, etc.)	32 Megabytes or more
Program memory (Flash) (for Linux OS, program storage, and file system)	64 Megabytes or more
Data-log memory (RAM) (for data log and retained variables)	Battery-backed – Rechargeable Lithium. The Contractor shall provide in his offer, the selection and sizing calculations with reference to the RTU regarding sufficiency of Memory and Processing power of RTU to handle all the specified functions, storage requirements, data-up date speeds, etc. shall be taken care of in the selection and sizing.
Battery-backup time and battery life	1year backup time and battery life of 10+years
Real-time clock	10Ms
Real-time clock	+/-15 seconds per month
Data log modes	Trending, alarm log, sequence of events, event initiated, client transfers, and others

IEC	Yes
Language support	At least two or more from Ladder logic, function chart, function block, instruction list, structured text, and flowchart
Cycle time	10 ms minimum (user settable)
Communication capabilities	Master, slave, peer to peer, report on exception
Communication	Ethernet (TCP/IP) and RS485(MODBUS)
Telemetry(built-in)	Built-in GPRS (4G & 5G);
CPU watchdog	CPU automatically resets if error is detected; status LED flashes error code
Ethernet Port	Network port:1 shielded RJ45connector with Isolation to1.5kV rms/ 1minute Message response time (typical) – 5ms Diagnostic LEDs–(speed and activity) Protocols supported–TCP/IP, ARP, UDP, ICMP, DHCP, Modbus/TCP
Serial Ports	Two numbers RS232 PortRJ45/ DB9, atl east one RS485Port with Screw termination (support for full-duplex and/or 2-wire half-duplex) Protocols – MODBUS ,Software, RTS-party (for radios and RS-485)
Discrete Inputs	No.of channels:Atleast12, with ON Voltage 9 to 30VDC, OFF Voltage 0 to 5VDC Input Resistance: 10K Ohms, Input Current @ 24V / 3 Ma
Discrete Outputs	No. of channels :Atleast8(10-30VDC) with Maximum Output per channel of 1amp Typical ON resistance:0.3ohms and Typical ON voltage (@1A) – 0.3VDC
Analog Inputs	No. of channels (Twelve or Sixteen); At least two spare channels needed; A/D resolution – 16bits (0.003%),Full scale accuracy-+/-0.1% (@20deg.C) Input impedance – 100 Ohm, Differential mode rejection 66Db at 50/60Hz
Input voltage	10to30VDC (integrated switching supply)
Temperature	-40 to 70°C (-40 to 85°C storage)
Humidity	5% to 95% RH (non-condensing)

Mounting	DIN rail

VI. HMI / PANEL PC

Specification	**Requirement**
Front Bezel:	Aluminum w/IP65/NEMA4 rugged protection
LCD Panel:	Display size 15” colour or greater LCD.
	Brightness 350nits
	Resolution 1280 x 1024 pixels
	Viewing Angle80°/80°
	Display Size:15” minimum
Main System:	CPU LGA1155 socket 3rd &2nd Generation Intel®Core™i7/i5processor
	System Memory 2 x 204-pin DDR 3SO-DIMM max.upto16GB
	Storage 2 x 2.5” SATA HDD
	Drive1xbuilt-in slim DVD-RW (optional)
	Watchdog Timer 255 levels, 1~255sec.
Operating System:	Latest Windows .(Contractor shall submit compliance test report w.r.t various applications, functionality)
IO Connector:	3 x RS-232 (COM2-4)
	1 x RS-232/422/485 (COM 1)
	1 x RS-232 with 5V & 12V (COM 3)
	1 xDVI-D
	1 xVGA
	6 x USB 2.0(back)
	2 x USB 2.0(front)
	2 x 10/100/1000 Mbps Ethernet
	1 x Audio (Mic-in/Line-out)
Touch screen:	5-wire resistive type
	1million activations (typical) at a single point
Power Supply:	100 ~ 240VAC,270W
Dimensions:	469 mm (W) x 94.7 mm (D) x 380.8 mm(H)
	Operating Temperature: 0° ~ +45°C (+32°F ~+113°F)

Environment:	Storage Temperature: -20°C ~ +65°C (-4°F ~+149°F)
	Relative humidity:10~95%@40°C, non-considering
	Operating vibration: 1.0G, 5-500Hz, random
Processing and Memory	The Contractor shall provide in his offer, the selection and sizing calculations with reference to the HMI regarding sufficiency of Memory and Processing power of HMI to handle all the specified functions, storage requirements, data-update speeds, etc. shall be taken care of in the selection and sizing.

VII. DC Power Supplies

Specification	**Requirement**
Nominal input voltage	230VAC
Frequency	47 Hz to 63Hz
Input current	3.2 A typ. At 230VAC
Mains failure hold-up time	> 20 ms at 230VAC
Nominal output voltage	24VDC
Output current	10 A at 24VDC
Adjustment accuracy	1%
Degree of protection	IP20
Operational indication	LED green (24VDCo.k.),LED red(overload)
Type of mounting	DIN-rail mounting (DINEN50022)
Ambient	-10 °C to+70°C
Wire Connection	Cage Clamp
Type	SMPS, shielded metal case, with provision for earth

VIII. Intrinsic Safety Barriers

Specification	**Requirement**
Channels	Isolation type IS Barriers, DIN Rail mount
Type	DC version, positive polarity
Nominal resistance	300Ω
Fuse rating	50Ma
Working voltage	Max. 27 V , 26.5 V at 10 µA
Degree of protection	IEC60529
Ambient temperature	-20 ... 60 °C (-4 ... 140°F)

Storage	-25 ... 70 °C (-13 ... 158 °F)
Degree of protection	IP20
Mounting	Standard35mmDINmountingrail (EN60715:2001)
Group, category, type of protection, temperature class	II3GExNaIICT4Gc[deviceinzone2]
Directive94/9/EC	EN 60079-0:2009, EN 60079-11:2007, EN 61241-11:2006 , EN 60079-15:2010
IEC Ex approval	IEC Ex BAS09.0142

IX. Surge Protection Barrier

Specification	**Requirement**
Channels	1-Channel
Rated voltage Un	≤30V
Rated current In	≤250mA
Leakage current	≤5μA
On-state voltage	≤45V
Nominal discharge current (8/20)In	10kA pe rcore,5kA per core(10x)
Max. surge current (8/20)Imax	20kA per core,10kA per core(1x)
Degree of protection	IEC60529
Ambient temperature	-30...80°C(-22...176°F)
Degree of protection	IP20
Mounting	DIN rail mount module
Group, category, type of protection, temperature class	Ex II 2(1)G Ex ia IICT6
Directive94/9/EC	EN60079-0:2006,EN60079-11:2007
IEC Ex approval	IECEx BAS14.0010X

X. GPRS Gateway

Feature	**Technical Specifications**
Cellular Interface	SIM:2 x Mini SIM (2FF), connector:SMA-K, Antenna:2 (MAIN + AUX)
Ethernet	2 x 10/100 Mbps, 2x LAN or 1x LAN + 1x WAN port

Interface	
Wi-Fi Interface	Frequency Band:2.4 Ghz, Security:WEP, WPA,WPA2
Serial Interface	RS232 or RS485 (software configurable)
Network Protocols	PPP, PPPoE, TCP, UDP DHCP, ICMP, NAT, HTTP, HTTPs, DNS, ARP, BGP, RIP, OSPF, NTP, SMTP, Telnet, VLAN, SSH2,DDNS, etc.
VPN Tunnels	DNP3, IPsec, Open VPN, GRE, Wire Guard, Modbus RTU Gateway
Firewall	Web, CLI, SMS
Remote Management	Transparent, TCP Client / Server, UDP, Modbus RTU Gateway
Power Supply	9-36 V DC
LED Indications	1 x RUN, 1 x MDM, 1 x WIFI, 3 x RSSI
Built-in	Watchdog Timer

XI. MANAGED ETHERNET SWITCHES

Feature	**Technical Specifications**
Power Supply	100-240V AC 50/60 Hz
Interface	24 x 10/100/1000BASE-T ports 2x Gigabit SFP Slots

XII. Broadband Internet

Broadband internet services with high speed connectivity shall be supplied for connectivity with MIS-2 centralized SCADA center and for web connectivity. The most suitable package of broadband internet service provided by an Internet Service Provider (ISP) which suits the Client's requirement shall be utilized. The Contractor shall enter in to SLA agreement to provide continuous fail safe services as required under this contract.

XIII. Fixed Line

For locations at where ISP is readily available, the technology which supports the broadband services shall be based on Digital Subscriber Line (DSL). The type of DSL utilized shall be of the Asymmetrical Digital Subscriber Line (ADSL) which shall allow simultaneous access to the net and usage of the telephone or fax line Certified ADSL modems shall be utilized. Splitter and micro filter shall be installed on the telephone or fax line to avoid interference.

XIV. A3 COLOUR LASER MULTIFUNCTIONAL PRINTER:

Color Multifunction printer shall be used for the production of color screen dumps and reports and shall have a sufficiently sized buffer memory such that system performance will not be degraded when the color printer is operational and comply with the following:

Feature	**Technical Specifications**
Functions supported	Print, Copy, Scan, Send and Optional Fax
Interface Connection	Network Standard:1000Base-T/100 Base-TX/10Base-T, Wireless LAN (IEEE 802.11 b/g/n) others Standard: USB 2.0 (Host) x 2, USB 2.0 (Device) x 1

Supported Media Sizes	Multi-purpose tray: Standard Size: SRA3,A3,A4, A4R, A5, A5R, A6R, B4,B5,B5R
	Upper Cassette: Standard Size: A4,A5,A5R,A6R,B5
	Lower Cassette: Standard Size: A3,A4,A4R,A5,A5R,A6R,B4,B5,B5R

13.40 Uninterruptible Power Supply (UPS) for Instrumentation, Control & Automation

The UPS shall be floor mounted; self-contained and metal clad and shall be suitable for supplying a non-linear load. It shall be possible to open the enclosure front door when the unit is in use without exposing any live contact to touch.

The complete UPS system shall be installed in a separate room in the administration building, with a separate room for batteries.

The UPS shall be an on-line type incorporating a six pulse rectifier and pulse width modulation inverter technology with microprocessor control. It shall incorporate a static bypass switch which shall operate in the event of UPS failure, overload or manual initiation in order to transfer the output supply to mains without disturbance to the output supply.

The UPS shall incorporate a dc under voltage trip circuit to electronically trip the UPS output in order to protect the batteries.

The noise level of the unit shall not exceed 60dB(A) at 1 m from the UPS cabinet.
The output of the inverter shall be a sine wave having less than 2% THD for linear loads and less than 4% for 50% non-linear load. It shall be suitable for load power factors 0.7 lag to 0.9 lead.

The unit shall have a dynamic response such that a 100% step load causes an output voltage transient of less than ± 4% with a recovery time of less than 4 ms.
For three phase output units the output voltage shall not vary by more than ± 1% for an unbalance of 10%.

The load crest factor shall not be less than 3:1.

The efficiency at full load and 0.8 power factor shall be greater than 88%.

The UPS System shall communicate the following status data to the plant SCADA system to monitor: (Note: To be demonstrated during FAT)

- UPS status
- UPS alarm conditions
- Battery capacity
- Bypass status
- Fault

The UPS shall provide a volt free contact output to indicate:

- warning, i.e. low battery capacity
- fault
- static bypass in use.

The UPS shall have an overload capacity of 150% for 30 seconds and shall be protected in the event of a short circuit of the output.

The batteries shall be housed, either within the UPS enclosure or within a separate matching battery cubicle suitable for location adjacent to the UPS. The UPS battery shall be located in a well ventilated area.

a) Technical Particulars:

Each UPS shall have the following features:

a) The UPS shall be redundant, true on line, based on advanced IGBT PWM technology with microprocessor based control, monitoring and fault diagnostics, static by pass switch and front access oriented layout.

b) Main Parameters:

1	Input Voltage	415V +10% -15 % A.C. Three phase 4 wires with Solidly earthed Neutral.
2	Symmetrical Short circuit level. Frequency	25kA 50Hz ± 5%
3	Output Voltage	240 ± 1% A.C, Three Phase 4 wire with Solidly Earthed Neutral.
4	Frequency Wave form	50Hz ± 5% True Sine Wave
5	Isolation	True on line with complete galvanic Isolation
6	Total harmonic Distribution	< 2% for linear load, < 3% for non-linear load
7	Over load Capacity	125% for 10min 150% for 10Sec
8	Transient Response	Remain within ± 1% and recover to 100% within ¼ Cycle
9	Crest factor	3 : 1
10	Duty	Continuous
11	Static by pass	to be provided
12	Efficiency Converter Inverter Overall	 > 94% > 93% > 87%
13	Max Ambient Temp and Relative Humidity	45°C & 100%
14	Cooling	Forced air
15	Acoustic Noise Level	<60db at 1.5m
16	Battery backup	120min for full load.(For WwTP)

		60 min on full load (For ISPS)

c) The UPS shall be complete with Isolation transformer, Converter cum Changer, inverter, protections, indications, programming, microprocessor based monitoring and fault diagnostic system, communication facilities, redundant control power supplies, SMF battery, accessories and interconnecting Cables.
d) Constructional Features: The UPS shall be high quality CRCA sheet steel enclosed suitable for floor mounting. The sheet steel shall be of 2mm thick. All sheet parts shall undergo a phosphating process to ensure anti-rust conditioning and a superior finish. Premier quality powder coating shall be applied. The degree of protection shall be IP 54. The UPS panel shall be provided with two earthing terminals. The final finish shall be Light Grey Semi Glossy Shade 631 of IS 5.

Converter cum Charger:
When normal AC supply is available, DC power for the inverter is fully supplied by the converter and the battery is kept under float charge. On main supply failure, the battery shall be automatically connected to the Inverter without interrupting the output voltage for critical load. Similarly on normalization of AC power, the DC load shall be transferred to the converter and battery shall be put on float charge without interruption at output side. The converter cum charger shall be designed to deliver the full load DC required by the inverter and charging of the battery. Battery charging shall be with float & boost mode selection with current limit.

1) Inverter:
The static inverter shall convert the power from the converter/battery into stable AC power which is supplied to load. The inverter shall be with the latest IGBT PWM technology with specially designed output transformer.

2) Battery Bank:
Batteries shall be 12V, SMF (sealed maintenance free) type. The Qty & AH of batteries shall be suitable for backup period of 120 minutes for full load for WwTP and backup period of 60 minutes for full load for ISPS .

The battery shall be rated to provide full load power for the required backup time on AC power failure. After delivering this amount of power, the battery shall be suitable for recharging through converter cum charger on AC power restoration. The battery shall be mounted on a separate rack. The battery bank shall be complete with battery stand, interlinks and UPS to battery interconnecting cable.

The battery bank shall be installed in a separate room with good ventilation in the administration building.

3) Other features:
The other features of UPS shall be as follows:

i) Microprocessor based Control, monitoring and fault diagnostics.
ii) Comprehensive LED mimic and LED display with keypad Control to enable the following:
a) Date-time stamped event recording and logging in a non-volatile memory
b) Programming and Monitoring of various system parameters
c) Status indications and number of LCD digital meters.
iii) 100% Nonlinear local handling Capability with low distortion of less than 5% and high crest factor of 3:1
iv) RS 232c/ RS 485 interface port.
v) Front access layout.

vi) Inbuilt line chokes for main power supply.

vii) Indications:

- Mains 'ON'
- Converter 'ON'
- Inverter 'ON'
- Battery Low
- Over load
- Inverter Trip
- Charger Trip
- Output 'ON'

viii) Protections:

- Incomer MCCB with Overload & Short circuit releases
- Outgoing MCCB with Overload & Short circuit releases
- Battery MCCB with Overload & Short circuit releases
- Input under/over voltage
- Converter over voltage
- Battery Low
- Battery charging current limit
- Output under voltage
- Output over voltage
- Output over load
- Output short circuit
- Inverter over temp
- Single phase prevention

Alarm and trip conditions shall be separately enunciated.
The backup period shall be minimum 2 hr on full load.

4) Testing Requirements

The Contractor shall carry out specified tests as follows in addition to any tests stated or implied by the foregoing sections of this clause.

The tests shall be carried out on the fully assembled unit utilising the batteries that are to be supplied with the unit.

The Contractor shall demonstrate the following on a minimum:

- change-over from full load with mains present to full load on battery supply;
- carry out a discharge test on the system at full load and for the specified duty bridging time period;
- carry out recharge test after operation for the specified duty bridging time at full load. The UPS shall supply the full load during the recharge cycle.
- Demonstrate the full functioning of the PLC& SCADA system while running on UPS power.
- All Routine/acceptance tests as per relevant Indian / International standards shall be carried out in the presence of Employer / his Employer Representative

5) Quality Assurance/Quality Control (QA/QC)

QA/QVC shall comply with the Contract, with particular requirements specific to the equipment or service being provided as outlined below for PLC & SCADA systems and other equipment that shall comprise the instrumentation and automation system under this contract. The quality assurance/control procedures shall include, but not be limited to the following:

- Continuity and Wiring tests;
- Insulation and High Potential Testing;
- Complete functional test inclusive of calibration;
- Packaging and Shipping;
- Welding;
- Cleaning and Painting.

The quality assurance/quality control documentation shall include, but not be limited to the following:

- Material Certifications;
- Shop Test Reports;
- All other documentation required by applicable codes and standards.

13.41 SCADA Control Room design

Design Considerations

An ergonomic approach to the design of centralized SCADA monitoring center workstations and the layout of the control room shall contribute to achieving safety and performance objectives set for the centralized SCADA room.

Effective control room design shall consider safety and performance / aesthetic objectives and function to create workspaces that facilitate the complex interaction between operators, technology and the environment. Raised flooring, acoustic concerns, indirect lighting and the wellbeing, health and safety of each operator shall need to be addressed.

Operators in the control room shall work 24 hours a day, 7 days a week.

Control room design shall take into consideration room size, number of operators, viewing requirements and equipment. Operators shall be able to communicate with each other as well as have easy access to essential equipment. The height of the console shall be calculated so the shortest operator can see over the top of any workstation mounted electronics to remote monitor walls, control panels or displays and the clearance underneath the work surface should allow for the tallest operator to sit comfortably.

When designing the control room to address these and other concerns, the following steps shall be taken to ensure operator comfort and minimize fatigue:

- Test console layout with operators for “human tasks” including sequential task simulations.
- Develop workstation layouts designed around acceptable reach zones and visual limitations.
- Take into account maintenance requirements and removal of equipment from both the rear and front of the workstation.
- Provide ergonomic footrests where appropriate.
- Provide 24/7 chairs with full adjustment capabilities.
- Reduce excess heat and noise by locating electronics in an equipment room.
- In workstation dimensions, consider the full height and size range of the operators, utilizing height adjustable work surfaces where appropriate.

The SCADA control room shall be constructed to a high standard to provide a high profile feature and focal point for visitors to the WwTP.

SCADA control room and associated areas shall be equipped with false flooring & false ceiling. The entire control room and associated areas shall be provided with air-conditioning systems (at least two nos of 2 tonne air conditioners in the main control room & server area).

SCADA control room shall be designed to have maximum view of the plant and plant operation. The brick masonry works in the control room shall be replaced with full length glazed windows with access control system and CCTV system to prevent un-authorised access .No UPS system shall be installed in the control room. A separate UPS room ,separate battery room shall be provided in the administration building for the purpose.

The SCADA control room shall be equipped with false flooring to provide access for all cables. No cables shall be installed over the control room floor.

The SCADA control room shall be provided with air conditioning system .The temperature in any area of the control room shall not exceed 22deg C

1. Electrical & Earthing Requirements for SCADA control Room

SCADA Control room Power distribution system shall have redundancy at two levels. The electrical system shall be designed to incorporate spare capacity (Minimum 20%) at each distribution level. All wiring up to the SCADA Control room shall be laid in powder coated MS conduits / Aluminum raceway.

All power cables up to the SCADA Control room shall be PVC insulated type. All cables shall be armored cable type except where flexibility required does not permit use of armored cable.
Earthing system shall be as per IS – 3043.

Contractor shall design and implement anti- static EMI / RFI protection arrangement, wherever necessary.

The Contractor shall design, engineer, supply/manufacture, test, erect, install, connect; commission and site test the Electrical Distribution System for any and all power requirements within the SCADA Control room facility. This shall include, but not be limited to UPS, Lighting system, ACDB system and input power to various sub systems of the Server/SCADA Control room like cooling units, alarm systems etc.

Design, engineering, supply, section, wiring, commissioning and testing of all systems are in the Contractor scope. Contractor shall design, engineer, supply, commission and test the electrical system considering the various loads it has to cater to.

The technical specifications and the scope for various items provided herein need to be verified by the Contractor. Contractor's scope shall include end to end system that is designed and implemented according to various applicable standards / regulations and meets total requirement for the Server/SCADA Control room Facility.

Copper earth pit station as per IS - 3043 using 600 X 600 X 3 mm copper earth plate complete with accessories and hinged cover shall be provided by the Contractor. Another earthing system shall be extended for equipment body earthing of SCADA control room, using 25 X 6 mm copper strip. Two Earthing pits shall be provided for UPS Earthing, which will be interconnected, and same grid will join the building-earthing grid at only one point. Earthing System shall be designed & maintained considering

personnel safety and noise-resistant electronic environments by providing equi-potential bonding with earth resistance of less than 3 ohm. Contractor shall design, supply and implement the most efficient and safe earthing system considering the types of load, fault conditions, cross current circulation, spikes, circulating current due to potential differences, etc.

The earthing system implemented shall ensure safety of people and systems under all conditions. Earth fault protection shall be designed and implemented by the Contractor for all loads

2. Fire Alarm System

The Contractor scope of work shall include at a minimum, design, engineering, supply and installation & commissioning of Fire Alarm System suitable for control room and all ancillary facilities area.
Fire Alarm System (FAS) shall be designed to detect & suppress the incipient fires and generates audio/ visual alarms in case of fire. The system shall consist of automatic fire detectors and manual call point & break glass units. Automatic fire detector shall work on principle of sensing the smoke, heat or infrared rays.

Detector shall be provided in control room and various location in the administration building. Manual call point shall be provided at exit doors/ routes of control room. Number of detectors and manual call point shall be decided as per guideline and codes.

Fire alarm system shall be microprocessor based fire alarm system and shall have addressable type field devices. It shall comprise following equipment's used in conjunction with addressable automatic detectors & and addressable MCPs.
1. Multi loop Data Gathering Fire Alarm Panel (DGFAPs).
2. Sirens & Starters, Hooters, exit signs.
3. Interface with other systems thru Dual redundant data highway with complete network hardware.

System shall be modular and facilitate future extension up to 20%. Redundancy shall be provided at Processor, communication, power supply level. Fire alarm logic shall be programmable type. Minimum number of detectors/ MCPs/ addressable devices in single loop shall be 60 nos. Conductor size of loop cable shall be 1.5 sq. mm copper. All field devices like detectors, MCP shall be addressable type. Fire alarm system shall be interfaced with Fire extinguishing system.

3. Fire Extinguishing System

Design, engineering, supply and installation commissioning, puff test, guaranteeing of total flooding (above false flooring + control room + below false flooring) clean agent Fire Extinguishing system for Fire Protection is nitrogen gas.

All equipment's shall be approved by UL/FM/Vds/ LPC and TAC accredited agency. Cylinders along with cylinder valve shall be seamless and PESO approved. Clean agent system to be provided shall meet the requirement.

The system shall include electrically actuated automatic clean agent Fire extinguishing system complete with filled up clean agent cylinders, cylinder rack, manifold, pressure reducing devices, cylinder valves, directional valves, pipes, discharge nozzles, bracket supports, hangers and such other fittings necessary for complete installation of system including necessary civil and mechanical work to complete the above work.

System shall be in operation in following modes

1. Automatically due to fire detection in protected area.
2. Operation of manual release push button located adjacent to protected area.
3. By operating manual lever provided on electrical/ manual control head on pilot cylinder
4. By push button actuation at clean agent control panel.

The system shall include electrically actuated automatic clean agent Fire extinguishing system complete with filled up clean agent cylinders, cylinder rack, manifold, pressure reducing devices, cylinder valves, directional valves, pipes, discharge nozzles, bracket supports, hangers and such other fittings necessary for complete installation of system including necessary civil and mechanical work to complete the above work.

The clean agent shall be discharged / actuated automatically after an adjustable time delay based on the detection signal received. The delay shall be minimum 30 seconds; however it shall be adjustable from 30 to 120 sec. Local control panel of control agent shall be equipped with Hooter. It will operate once gas is released.

4. False flooring:

Finished height of Access floor up to 450mm Raised flooring shall be provided.

a. The raised floor must be capable of withstanding a uniform load of 1,220 kg/m2 with a maximum deflection of 2.5 mm.
b. The recommended panel size for the raised floor is 610 mm square. These panels must be easily removable to facilitate access to the under-floor area. Special weather coating on back side of the tiles to be provided.
c. The raised floor must be level within +3.2 mm overall and within +1.6 mm in any 3.05 m (10 ft) distance.
d. Fire resistance of floor material must comply with more stringent, local regulations. It should be totally fire proof.
e. The metallic structure of the raised floor must be electrically bonded to the ground to minimize static buildup. The floor panels must have conductive contact with either the framing, the pedestals, or both for positive electrical grounding.
f. Panel surfaces must be high-pressure laminate. Do not use carpeting. Use material that is both dust and crack resistant. The material must withstand movement of heavy equipment on casters and must resist the buildup of static electricity. Cleaning products containing ammonia must not be used.
g. All cable openings in floor panels must have plastic edging to prevent damage to cables
h. Provide adequate drainage to ensure that no moisture accumulates in the recessed area.

Following provisions for the computer system between the raised floor and the primary floor: shall be provided:

- AC power distribution for the computer system
- Input/output cables.
- Air ducts or passages for cooling air
- Cable ducts

Clearance between the raised floor and the primary floor is 450 mm.

i. The cables are to be routed along the under floor and brought up to the cabinet locations prior to placing the cabinets.
j. Ensure that at least 102 mm (4 in.) of free space exists between the top of the under-floor cables and the raised floor. Route the cables so that excessive buildup does not occur in any local area. Cables routed under the floor that are to connect to electronic equipment must be routed so that excessive strain does not occur on the connector due to inadequate space for bent radius of the cable. In the case of the large diameter input/output cables for peripheral equipment, provide a minimum bend radius of 212 mm (6 in.). All cables are to be routed at 90 degree angles. Power and signal cables must be separated by 150 to 300 mm to minimize noise interference.
k. Matching/approved profiles to be provided.

5. Industrial system console for SCADA control room:

The Industrial system console solution shall be capable of performing 24X7 operations under the specified environmental condition. It shall conform to high standard of engineering as mentioned in the document; meeting the specified codes, designs and standards. All the certificates and reports mentioned below shall be submitted as part of datasheet submission. Entire system console shall be Green guard Gold and UL certified. The system console shall be sized to accommodate the complete SCADA system and its ancillaries inclusive of but not limited to the following:

1. Redundant SCADA servers
2. Operator and engineering work station
3. Historian station
4. CCTV station
5. Managed Ethernet switches
6. Online printers
7. Other ancillaries

The entire Industrial system consoles shall be warranted for minimum five years against any manufacturing defect.
The Color scheme of the system console shall be as per BWSSB requirements and shall be decided during detailed engineering.

Vendor Qualification criteria for design and supply of Industrial system console:

The agency which shall design, supply, install and commission the industrial system console equipment, on a minimum**,** shall be operating under an accredited ISO 9001:2015 system, with a minimum of 10 years' experience of having designed, supplying and installation of system console. The agency shall have proven track record of supplying similar console as required under this contract, to at least five control room projects. The agency shall have In-house metal manufacturing & automatic Powder Coating Plant.

Minimum Design Criteria for System Console:

Structure: -

Shall be made of heavy duty Extruded Vertical and Horizontal Aluminium profiles of HE9WP grade. The Extrusions shall be duly powder coated with 40+ micron over all surfaces.

To allow future extension and expansion, a weld free system shall be proposed. Interconnecting joints shall not be visible. The structure shall allow easy assembly of Hinged Shutters, Slat wall, Gland Plate, Monitor arms in extremely rigid manner.

Industrial system console shall be Seismic Zone 2 tested and certified with monitor mounted on monitor arms of the console. Seismic test report of bare Industrial system console shall be deemed unacceptable. Test report with images of Industrial system console seismic test should be enclosed along with the datasheet submission.

Table top: -

The material of the working surface shall be minimum 25 mm thick MDF with High Pressure ANSI/NEMA LD3 certified scratch-resistant Laminate.

Front Edge: - shall be UL Certified design with modular Polyurethane (PU) Edge. High density Poly Urethane Foam moulded on industrial grade aluminium core to form 50mm deep tapered edge shall be installed on worktop. UL Certificate to be enclosed along with datasheet submission.
Slat Wall shall be made of minimum 2mm thick Extruded Aluminum (HE9WP aluminum alloy) and designed in such a way that no joints or gaps are visible in the entire width of the console. The console should be UL Listed and certificate shall be submitted along with datasheet submission.
UL Certified design feature on Monitor Arm Assembly shall have auto-lock, push & add/remove die-cast aluminium extendible arms of 150mm each with tool less addition/deletion feature to cater future requirements.

Shutters & Side Legs: - Front, back shutters shall be of minimum 18 mm Laminated MDF Board with premium finish. Side leg shall be of 25mm of the same finish. Hinges shall have lifetime warranty against manufacturing defects. Warranty certificate shall be submitted along with the datasheet submission.

Cable Trays and Wiring: - The control system console shall be designed with vertical and horizontal cable trays to allow for continuous cable management between the cabinets. Wire shall be routed into the cabinet through gland plate.
Hardware: - All bolts shall be of SS material to avoid rust due to environment. Remaining hardware shall be Nickel Plated with RoHS certificate.

End of Part-13

PART 14

INSPECTION, TESTING AND COMMISSIONING REQUIREMENTS

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PART-14

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PART 14

INSPECTION, TESTING AND COMMISSIONING REQUIREMENTS

14.1 Inspection and Testing During Manufacture

14.1.1 General

(a) All inspection and testing shall be carried out in accordance with the Specification and in the absence of Specification relevant Indian Standard or internationally approved equivalent standard. After award of Contract, Contractor shall furnish a QA plan for approval by Employer. QA plan shall include testing for incoming supply of raw materials and bought out items, stage inspections and tests on finished products at manufacturer's works / appropriate testing station. QA plan shall clearly indicate tests which are intended to be witnessed by the Contractor alone and those by both Contractor and Employer.

(b) **Inspection and tests schedule shall be as follows**

1) Manufacture tests
2) Acceptance inspection / Quantity checking
3) Install / site inspection / Site acceptance test
4) Tests on Completion
5) Process Wet Tests (by Raw Sewage)
6) Operation Test (Tests After Completion)
7) Complete performance tests of Plant after 10-year Operation (Before plant handing over)
8) Test furnished as per IS Code/manufacturer QAP

(c) The Contractor shall carry out at the place of manufacture tests of the Plant /Equipment at any part of the Works as per approved QAP.

(d) The Employer and/or duly authorised and designated representative(s) shall be entitled to attend the aforesaid inspection and/or tests.

(e) The Employer and his duly authorised representative shall have access to the Contractor's premises at all times to inspect and examine the material and workmanship of the mechanical and electrical plant and equipment during its manufacture there. If part of the plant and equipment is being manufactured on other premises, the Contractor shall obtain permission for the Employer or his duly authorised representative, to inspect as if the plant and equipment was manufactured on the Contractor's own premises. Testing (including testing for chemical analysis and physical properties) shall be carried out by the Contractor and certificates submitted to the Engineer who will have the right to witness or inspect the above-mentioned inspection /testing at any stage desired by him. Where inspection or testing is to be carried out at a subcontractor's works, a representative of the Contractor shall be present.

(f) Contractor shall provide test procedure, pre-factory test results, and calculation sheet, photo in advance, and provide all test results with necessary documents, including its data and photo, to show the Engineer that the test is carried out in proper condition and its test results. Construction material shall be tested by Contractor at the approved laboratory

(g) The procedure for testing and inspection to be carried out during or following the manufacture of the materials, to ensure their quality and workmanship, and to further ensure that they conform to the Contract, shall be as described below.

(i) The Contractor shall provide the Employer with at least 21 clear days' written notice of the date and location at which any plant or equipment will be ready for inspection and testing, as specified in the Contract. Prior to notice, the Contractor should submit pre-factory test results as per clause 14.1.1(f). The Employer or his duly authorised representative shall thereupon, at his discretion, notify the Contractor of his intention either to release such part of the plant and equipment upon receipt of works tests certificates or of his intention to inspect. The employer shall then give notice in writing to the Contractor and attend at the place so named the said plant and equipment which will be ready for inspection and/or testing. As soon as any plant has passed the tests referred to in this section, the Engineer shall issue a notification to that effect to the Contractor, after obtaining clearance from the consultants.

(ii) The Contractor shall forward to the Employer 6 duly certified copies of the test certificates along with characteristics performance curves/tables if any for all equipment obtaining dispatch clearance from the consultants/Engineer.

(iii) If the Engineer(s) fails to attend the inspection and/or test, or if it is agreed between the parties that the Engineer(s) shall not do so, then the Contractor may proceed with the inspection and/or test in the absence of the Engineer and provide the Employer with a certified report of the results thereof as per (ii) above.

(iv) If any materials or any part of the works fails to pass any inspection / test, the Contractor shall rectify or replace such materials or part of the works and shall repeat the inspection and/or test upon giving a notice as per (i) above. Any fault or shortcoming found during any inspection or test shall be rectified to the satisfaction of the Engineer before proceeding with further inspection of that item. Any circuit previously tested, which may have been affected by the rectification work, shall be re-tested.

(v) Where the plant and equipment are a composite unit of several individual pieces manufactured in different places, it shall be assembled and tested as one complete working unit, at the manufacturer’s works.

(vi) Neither the execution of an inspection test of materials or any part of the works, nor the attendance by the Engineer(s) nor the issue of any test certificate pursuant to (iii) above shall relieve the Contractor from his responsibilities under the Contract.

(vii) The test equipment, meters, instruments etc., used for testing shall be calibrated at recognised test laboratories at regular intervals and valid certificates shall be made available to the Engineers at the time of testing. The calibrating instrument used as standards shall be traceable to National/International standards. Calibration certificates or test instruments shall be produced from a recognised/Laboratory for the Engineer’s consent in advance of testing and if necessary, instruments shall be recalibrated or substituted before the commencement of the test.

(viii) Items of plant or control systems not covered by standards shall be tested in accordance with the details and program agreed between the Engineer and Contractor’s Representative. If such materials or works are found to be defective or not conforming to the Contract requirements, due to the fault of the Contractor or his sub-contractors the Contractor shall defray all the expenses of such inspection and/or test and of satisfactory reconstruction.

(ix) Tests shall also be carried out such that due consideration is given to the site conditions under which the equipment is required to function. The test certificates shall give all details of such tests.

(x) The Contractor shall establish and submit a detailed procedure for the inspection of materials or any part of the works to the Employer for approval within the date indicated in the Programme Details. The detailed procedure shall indicate or specify, without limitation, the following:

- Applicable code, standard, and regulations.
- Fabrication sequence flow chart indicating tests and inspection points.
- Detailed tests and inspection method, indicating the measuring apparatus to be used, items to be measured, calculation formula, etc.
- Acceptance criteria.
- Test report forms and required code certificates and data records.
- Method of sampling if any sampling test to be conducted.
- Contractor's or Employer's witness points.

(xi) The Contractor shall not pack for shipment any part of the Plant until he has obtained from the Employer or his authorised representative his written approval to the release of such part for shipment after any tests required by the Contract have been completed to the Employer's satisfaction.

(xii) The following Inspection and Testing procedures shall be carried out for the equipment as per approved QAP. The detailed procedure shall indicate or specify, without limitation, the following:

- Raw Material
- Visual Inspection/Appearance.
- Chemical and Mechanical property tests
- Dimension Checking
- Dynamic balancing for all rotating parts
- Stage inspection
- Hydrostatic / Leak testing for all pressure parts, Pneumatic Leak Test wherever applicable
- Repair procedure
- Operation check
- Procedure Qualification Record (PQR); Welding Procedure Qualification (WPQ) and Welders Qualification Report (WQR)
- Material Test
- Assembly/Connection
- Documentation

(h) The Contractor shall maintain proper identification of all materials used, along with reports for all internal / stage inspection work carried out, based on the specific job requirement and or based on the datasheets / drawings / specifications.

(i) The expenses incurred during inspection shall include, but not be limited to, travel, boarding, lodging, and out-of-pocket expenses.

(1) The Contractor shall be responsible for all expenses incurred by the Engineer or person/s nominated by the Engineer in attending inspection and tests of Plant carried out during manufacture within India and abroad. Two persons from Employer side will witness the

Inspection and testing along with the Contractor's representative. No separate payment will be made against to the inspection & testing, and same shall be included in bidder's quoted price.

(2) The cost of inspection when the material or any part of the facilities is not ready at the time specified by the Contractor for inspection, or when re-inspection is necessitated by prior rejection, shall also be borne by the Contractor.

(3) During all factory inspections, the authorized Contractor's representative should be present, along with the Employer and the third party. The authorized Contractor person who is attending the inspection shall be a qualified factory inspector based on the type of inspection.

(j) Witnessed testing will normally be waived on standard types of equipment such as small motors made by approved manufacturers, individual standardised instruments, small mass-produced components used in the manufacture of Plant items, small bore pipe work and fittings, minor installation materials and low voltage cable. In order to remove doubt this shall not relieve the Contractor of his obligation under the Contract to ensure that all Plant is tested at the manufacturer's works prior to delivery to Site.

(k) As a guide to the Contractor the Employer reserves the right to witness testing of the following but not limited to the following Plant items:

a) Electrical:

(1) 11/0.433kV Distribution Transformers
(2) 11kV Metal Enclosed Switchgears.
(3) 415V Metal Enclosed switchgears (PCC/PMCC/ MCC)
(4) 415V Distribution Boards (PDB, LDB, MLDB, Valve DB, Fan DB etc.)
(5) 415V Power Capacitor and Control Panel (APFC)
(6) Diesel Standby Generator with AMF Control Panel
(7) Battery, Battery charger and DC Distribution Board
(8) Variable Frequency Drives
(9) Soft Starters
(10) Non-Segregated Bus Duct
(11) Power & Control Cables
(12) Lighting System
(13) Earthing and Lightning Protection Systems
(14) Local Control Panels (LCP)
(15) Junction Boxes
(16) Cable Carrier System
(17) Solar PV system for Street Lighting or any other application.
(18) FAT & SAT for complete Electrical system

b) Mechanical:

1) TSPS Trash Screens with Motorized Monorail Hoist
2) TSPS Medium Screens with Screening Conveyor, Compactor and Screen Container including isolation gates
3) TSPS Pumps and dewatering pumps for wet-well including associated valves and fittings
4) TSPS Motorized Monorail Hoist

5) STP Fine Screens with Screening Conveyor, Compactor and Screen Container including isolation gates
6) Vortex Grit Mechanism with Grit Transfer Pump, Grit Washer Mechanism, Grit Discharge Conveyor with Grit Container including isolation gates
7) Parshall Flume Section
8) Primary Clarifiers with Plate Settlers and Primary Sludge Pumps including associated valves and fittings
9) SBR isolation gates
10) Alum mixer in SBR tank
11) SBR Decanter
12) MBBR Media
13) IFAS Media and frame
14) Ultrafiltration system
15) Greenhouse solar sludge drying system
16) Return Activated Sludge (RAS) and Waste Activated Sludge (WAS) including associated valves and fittings
17) Process Air Diffusers including associated valves and Fittings
18) Motorized Monorail Hoist for RAS and WAS Pumps
19) Process Air Blowers with acoustic hood including associated valves and Fittings
20) EOT Crane for Blower building
21) Alum Dosing Pump, tanks and mixers including associated valves and Fittings
22) Monorail, Chain pulley block with Travelling Trolley for alum dosing tanks
23) Disc Filters including associated valves, pumps, isolation gates and fittings
24) CCT isolation gates
25) Chlorinators, Chlorine Ejector, Booster Pumps, Chlorine Ton Cylinders, Load Cell, Motorized Monorail Hoist and Emergency chlorine scrubber including associated valves and Fittings
26) Centrifuge Feed Sump Mixers including lifting mechanism
27) Centrifuge Feed Pumps including associated valves and Fittings
28) EOT Crane for centrifuge feed pump house
29) Complete Auto Polymer System and Polymer Dosing Pumps including associated valves and Fittings
30) Decanter Centrifuge with Hoppers, cut gate, Conveyor and container including associated valves and Fittings.
31) Motorized Monorail Hoist for Decanter Centrifuge
32) Scum Transfer Pumps including associated valves and Fittings
33) Monorail, Chain pulley block with Travelling Trolley for scum sump and plant drain sump
34) Plant drain, plant water and traded water transfer pumps including associated valves and Fittings
35) Sludge Thickeners with feed pumps, Dilution water pumps including associated valves and Fittings
36) Digester Sludge feed pumps including associated valves and Fittings
37) Gas mixing blowers with Gas Lancers to digesters including associated valves and Fittings

38) Internal Recirculation Pumps to digesters including associated valves and Fittings
39) Digester heat exchangers with Hot water recirculation pumps, Hot Water Boilers and sludge recirculation pumps including associated valves and Fittings
40) Biogas storage tank, Biogas flare, Biogas scrubbing, Biogas dryer with scrubbing blowers including associated valves and Fittings
41) FAT & SAT for complete mechanical system

c) Instrumentation and Control:

(1) Level Measuring System
(2) Pressure Gauges
(3) Pressure Transmitter
(4) Flow Measuring System
(5) DO analyser
(6) ORP analyzer
(7) NH4-N and NO3-N sensors
(8) Temperature Measuring System
(9) Residual Chlorine Measuring System
(10) Instrumentation and Control Cables
(11) Instrument Control Panel
(12) Programmable Logic Controller
(13) SCADA / HMI System
(14) Uninterruptible Power Supply System
(15) Wireless GPRS gateway testing
(16) FAT & SAT for complete ICA system
(17) LIMS for the plant

(l) All destructively tested samples shall be replaced with brand new.

(m) The Employer reserves the right to be present during the testing and inspection of all Plant items.

14.1.2 Materials, Plant and Equipment

The Contractor shall place orders for the material and the equipment only after approval of QAP by the Engineer. The Contractor shall submit the detailed technical and its drawings from the approved manufacturer and the procedure of submission, review and revision shall be as specified herein below.

The Contractor shall inform the Employer about the likely dates of manufacturing, testing, and dispatching of any material and equipment to be incorporated into the Permanent Works. The Contractor shall notify the Employer for inspection and testing, at least twenty-eight (28) days prior to packing and shipping and shall supply the manufacturer's test results and quality control certificates.

The testing and approval for dispatching shall not absolve the Contractor from his obligations for satisfactory performance of the plant.

Dispatch Clearance

All mechanical/electrical/instrumentation equipment shall be tested at their respective factory which will be witnessed by tri parties (Contractor, BWSSB/Consultant inspecting team) in line with approved QAP and Equipment Data sheet.

The test observation sheets, material tests certificates (chemical and mechanical test at laboratory) and joint inspection report shall be signed by the Contractor, BWSSB/Consultant officials after successful completion of the tests.

Contractor shall forward all original reports to BWSSB and copy to the consultant for verification and issuance of Dispatch Clearance Certificates as per clause 14.1.1 g (ii). No Dispatch Clearance Certificate will be issued by the inspecting agency at the factory.

14.1.3 Factory Acceptance Test (FAT) Document

Fifty-six (56) days prior to commencement of inspection of each Plant item / equipment the Contractor shall supply a Factory Acceptance Test (FAT) Document for approval. This shall comprise four copies of the following:

- Unpriced copy of the Contractors order for the Plant item / equipment concerned:
- Details of the inspection and test procedures to be carried out.
- Pre-factory test results and its photos.

The FAT Plan shall provide comprehensive details of the tests to be carried out, the purpose of each test, the equipment to be used in carrying out the test and the methods to be adopted in carrying out the tests. The FAT shall provide space within the documentation for results of the tests to be added and for each test and for the FAT as a whole to be signed off by the Contractor and the Engineer.

On completion of the tests, the Contractor shall provide four (4) copies of all test certificates, curves etc. for the inspected Plant item. To remove doubt test certificates shall be provided for the Plant item as a whole plus certificates for the relevant component parts such as:

- Motors
- Mixers, pumps, and Blowers
- Instruments
- Gear boxes
- Electrical equipment
- Integral control and switchgear panels
- Valve gear
- Castings
- Actuators
- Cranes and Hoists
- Screens
- Diffusers
- Storage and process vessels
- Pumps /blowers
- Air blowers
- Centrifuge Decanters
- Chlorinators
- Heat Exchangers
- Storage and process vessels
- Clarifier and thickener bridges, drives, and sludge/scum mechanisms
- Vortex Grit Mechanism
- Chemical dosing systems complete with pumps, valves & tanks
- Mixers, pumps, and blowers including their motors, Valve, and penstock actuators
- Valves

- Pipes
- Sluice Gates
- Expansion/Dismantling Joints
- Weir Gates & Stop Logs
- Manual Coarse Bar Screen
- Mechanical operated TSPS Coarse Screens and STP Medium/Fine Screens
- Dewatering Centrifuge and associated plant
- Fine Bubble Diffuser systems
- Sodium hypochlorite Dosing system, Chlorination system and Cl_2-Gas Scrubbers
- Process Air Blowers
- EOT Cranes and Hoists
- Heat Exchangers
- Disc Filtration System
- Greenhouse solar sludge drying system
- Ultra Filtration System

14.1.4 Inspection and Testing Programme

The Contractor shall submit to the Engineer no later than 56 days prior to the commencement of the first inspection and test during manufacture a programme detailing the inspection dates for all Plant. Those items of Plant that the Engineer has specifically identified for witness testing shall be highlighted in the programme.

The Contractor shall keep the Engineer informed of any changes to the programme.

The Engineer shall not be requested to inspect an item of Plant until the Contractor has satisfied himself that the equipment meets all requirements of the the Employer's Requirements.

The Contractor shall inform the Engineer in writing at least 21 days in advance regarding readiness for carrying out inspection of equipment/material etc. at manufacturer's works or at places of inspection. The programme for inspection shall be finalised by the Engineer after the receipt of the above case equipment/material etc. Is found not to comply with the specification, the dates for re-inspection shall be finalised and expenses incurred by the Employer for such visits shall also be recovered from the Contractor. Contractor's Representatives shall essentially be present during all inspections of Plant items. The following information shall be given in the inspection call letter mentioned above:

(a) Name of manufacturer/supplier

(b) Address of place where inspection is to be carried out

(c) Proposed date/s and equipment to be inspected

(d) Name/s of contact personnel at manufacturer's/ supplier/s works with their telephone and fax numbers.

(e) Name of Contractor's Representative who will be present during the inspection.

(f) Confirmation that internal testing has been completed. Submission of internal testing report for review before visiting the plant

The Contractor shall provide all the necessary instruments, test facility, water / electric power, test piece, samples, engineers/ workers, all cost, and others to carry out the tests after assembly. All instruments used for such tests shall be calibrated and certified by, and approved by, an independent testing authority

within one month prior to the tests in which they are used. Calibration certificates with an expiration date and the name of the authorization agency for instruments used in such tests shall be produced for the Engineer's approval, and if necessary, instruments shall be recalibrated before the commencement of the tests.

No material shall be delivered to the Site without a Dispatch clearance certificate having been carried out or waived in writing by the Engineer.

If, during or after testing, any item of plant fails to achieve its intended purpose or otherwise proves defective, it shall be modified or altered as necessary and retested and reinspected as required by the Engineer.

14.1.5 Tests at Manufacturer's Premises – Mechanical Equipment

14.1.5.1 Sewage / Sludge Pumps

(a) All pumps shall be completely assembled in the shop to ensure correct fitting of all parts and shall be match-marked before shipment.

(b) All pumps shall undergo witness performance tests at the pump manufacturer's Works. Testing shall be undertaken using the respective job motor for all pumps supplied under the Contract.

(c) All tests such as Q/H curve, efficiency of pumps, power consumption, vibration and noise level shall be conducted, and NPSH tests one for each pumping station shall be undertaken to verify that the pumps meet the specified criteria. The pumps shall be run at constant flow capacity and speed.

(d) Pump casings shall be subject to hydrostatic pressure testing as an assembly at 150% of the pump shut-off head or 200% of the pump rated head whichever is higher. The hydrostatic pressure shall be held for not less than 30 minutes after all leaks have been stopped between attachments.

(e) Impeller and pump rotating assembly shall be dynamically balanced as per ISO 1940 Gr. 6.3 /ISO 21940-II: 2016/VDI 2060.

(f) Standard running test shall be conducted as per BS EN ISO 9906: 2012/ISO 9906:1999 at the rated speed at the manufacturer's works to measure the capacity, total head, efficiency, and power. These tests shall form the basis for pump acceptance except for vibration and noise. The pump shall be tested over a range comprising shut-off head to maximum flow. A minimum of seven readings approximately equidistant shall be taken for plotting the performance curve.

(g) The following formula shall be taken for computing the power input to the pump:

$$\text{Power input to the Pump in kW} = \frac{Q \times H \times 1.02}{367.2 \times \eta_p}$$

Where, Q = Discharge in cum/hr
H = Total head in mwc
η_p = Efficiency of pump

(h) If the vibration, noise level readings taken during performance test show higher than that permitted, vendor shall guarantee to show that the values shall be maintained at site after erection. Any cost of rectification needed on this count shall be borne by the Contractor.

(i) Stage inspection for pumps shall be carried out as per approved QAP. The Contractor has to make all necessary arrangement for witnessing the same.

14.1.5.2 Motors

All motors shall be inspected and tested at the manufacturer's works, and they shall be shipped in good packing condition.

The following tests shall be carried out, but not limited to:

(a) Specification and Quantity Inspection.

(b) Inspection Items

- Structural appearance inspection
- Mechanical inspection
- Wound wire resistance inspection
- Measurement of winding resistance.
- Insulation test
- Vibration test
- No-load test
- Captive test (Blocked rotor test)
- Phase sequence test
- Calculation of characteristics
- Secondary voltage measurement (wound-wire type)
- Revolution direction inspection
- Temperature rise inspection test
- Outer dimension inspection
- Paint inspection

(c) Main point for electrical equipment

- Private power generation
- Panels and related parts
- Performance test and inspection
- Independent power generation equipment
- Panels

(d) Routine Tests

All routine tests shall be carried out as per the latest edition of IS 12615/IEC 60034/IS 15999.

(b) Acceptance Tests

Full load test to determine efficiency, power factor and slip shall be conducted on all the motors.

(c) Type tests

The following type tests shall be carried out on one motor of each rating:

(i) Temperature rise test
(ii) Momentary overload test
(iii) Vibration measurement test
(iv) Noise level test
(v) Over speed test
(vi) Full load test to determine efficiency, power factor and slip
(vii) Starting current, starting torque and pull-out torque at reduced voltage

14.1.5.3 Valves Testing Factory

The following tests shall be carried out, but not limited to:

(a) Specification and Quantity Inspection.

(b) Dimensional check for each valve size.

(c) Physical and Chemical Properties Check of each valve Component.

(d) Hydrostatic Tests

(e) Motorized valves shall be tested with their actuators, with a differential head equivalent to their maximum working pressure, to prove that the actuators are capable of opening and closing the valves under maximum unbalanced head conditions within the specified opening or closing period.

(f) During testing, there shall be no visible evidence of structural damage to any of the valve components.

(g) The tests mentioned below shall be crucial and are to be witnessed by a duly authorized representative of the Engineer:

(h) In testing for valve seat leakage, the up-stream flange is tightly closed for a sluice valve or butterfly valves, the down-stream flange is closed for a check valve, and specified pressure are applied.

Work Test Inspection

- Manual Operation:
  Opening and closing direction of handle of smoothness, and switching manual operation and motor operation

- Motor Operation:
  Proper opening and closing of limit switch, opening and closing time, Voltage and amperes of motor, indication opening of opening angle gauge, operation of torque switch, working amperes of torque switch, confirmation of torque set scale, insulation resistance value, etc.

(i) Knife Gate valves, Gates and valves shall be tested as follows.
- Applying 1.5 times the rated torque.
- Assemble/dimension inspection,
- Structural appearance and dimension inspection,
- Non-load operation inspection and load test,
- Material/painting inspection,
- Bearings/backlash test/inspection on reduction gear.
- Magnetic particle tests on body and disc/door,
- Dye penetration tests on metal seats,
- Ultrasonic tests on shafts.
- Overload Torque Test for gear boxes,

(a) Butterfly Valves:

The following test shall be carried out for butterfly valves as per test procedure briefed in IS 13095:

(i) Seat leakage test at 1.1 times the rated pressure for a minimum duration of 2 minutes.
(ii) Body hydrostatic test at 1.5 times the rated pressure for a minimum duration of 5 minutes.
(iii) Disc strength test shall be same body test pressure and duration which will be one per size.
(iv) Valve operation with and without actuator.
(v) Pump discharge Valve:

(b) Knife Gate Valves &Sluice Valves:

The following test shall be carried out for sluice valves as per test procedure briefed in IS 14846:

(i) Seat leakage test at rated pressure for a minimum duration of 2 minutes.
(ii) Body hydrostatic test at 1.5 times rated pressure for a minimum duration of 5 minutes.
(iii) Back seat test at 0.5 times the rated pressure.
(iv) Valve operation with and without actuator

(c) Non-Return Valves:

The following test shall be carried out for non-return valves as per test procedure briefed in IS 5312:

(i) Seat leakage test at rated pressure for a duration of minimum 2 minutes.
(ii) Body hydrostatic test at 1.5 times rated pressure for a duration of minimum 5 minutes.
(iii) Operation for door opening and closing for the specified / designed duration.

(d) Air Valves:

The following test shall be carried out for Air valves as per test procedure briefed in IS 14845 or Equivalent:

(j) Seat leakage test at rated pressure for a duration of minimum 3 minutes.
(ii) Body hydrostatic test at 1.5 times rated pressure for the duration of minimum 5 minutes to check the water tightness of the body.
(iii) Operation.

(e) Expansion Bellows

The inspection and testing shall be conducted as per approved procedures. During testing there shall be no visible evidence of structural damage and no water leakage to any of the valve component.

The following tests shall be carried out, but not limited to:

i) Specification and Quantity Inspection.

ii) Hydrostatic Tests

- Body test pressure, 1.5 times of design pressure, and holding time, more than 3 minutes in testing for bellows seat leakage, which is maximum pressure in use.

iii) Work Test Inspection

- In testing for bellows for flexibility, and its maximum bending angle / deflection and stroke.

All certificates on the material's physical properties, heat treatments and shop test etc. of valve body, disc, wedge and shaft shall be issued by the manufacturer, which shall be subject to review & approval by Engineer/Employer.

Notwithstanding the above requirement for inspection and quality control, the following inspection, tests and quality control measures, but not limited to, shall be carried out by manufacturer:

(i) Assemble/dimension inspection, non-load operation inspection and load test, material/painting inspection, bearings/backlash test/inspection on reduction gear.
(ii) Structural appearance and dimension inspection, non-load operation inspection, martial/paint inspect on coupling
(iii) Magnetic particle tests on body and disc/door.
(iv) Dye penetration tests on metal seats.
(v) Ultrasonic tests on shafts.
(vi) Overload Torque Test shall be carried out on the gear boxes of the valves. The test shall be carried out by applying 1.5 times the rated torque.

Even though all the valves are tested at factory premises of manufacturer, Contractor has to establish test set-up at work site to test the valves along with their mating flanges bolted and spool pieces after welding to check the water tightness of the joints (no leakages in joints) and hydro test pressure shall be same as line pressure at site. After hydro testing the whole Valve assembly along with spools shall be lowered in the valve chamber and same shall be welded along the pipeline.

14.1.5.4 Pipe-work

The following tests shall be carried out:
(a) Material identification
(b) Welder qualification
(c) Edge preparation and weld set up
(d) Back chip where applicable
(e) Mechanical tests/production control test coupon tests
(f) NDT as required

The welding shall be checked by ultrasonic testing for all length, i.e. 100 % testing at the place of manufacture. Additionally, 10% of the weld joints shall be tested by radiography. All specials shall be tested 100% by radiography.

Testing of pipes and fitting shall be carried out in accordance with relevant Indian Standard and internationally approved standard. Pipes, fittings and expansion bellows shall be hydrostatically tested for 1.5 times the rated pressure. For all the tests specified, the certificates and shop records shall be duly approved and certified by the manufacturer, and these shall be subject to review & approval by Employer / Engineer.

14.1.5.5 EOT Crane & Hoist

The cranes shall be completely assembled in the Contractor's or subcontractor's Works and shall be subjected to the tests as specified in IS 807:2006 / IS 3177 or relevant internationally approved standard. The Contractor shall provide the test weights. Hoists and lifting equipment shall be assembled and tested at the place of manufacture in accordance with IS 3938.

The inspection and testing shall be conducted as per approved procedures. During testing there shall be no visible evidence of structural damage and no deformation.

The following tests shall be carried out, but not limited to:

(a) Specification and Quantity Inspection

(b) Structural Appearance Inspection
- Main pump test and inspection methods applied

(c) Functional test and Inspection
- Measurement of deflection

By slinging down piano weir or scale on the centre of beam and also on both ends a right and left and placing trolley at the centre, measurement of beam deflection under rate load is taken.

- Traversing and travelling measurement

Conform travelling and traversing under rate load. When test is not feasible at factory, the Contractor shall make a written request, which test is made at site after installation, to the Engineer for his approval.

(d) Operation and Speed Measurement
-Smoothness of all movement and no abnormal noise, vibration, sliding observed.
-Each speed during-hoist-up hoist-down, traversing and travelling under rate load is measured.
-Brake test under sling 125% load, lower at full speed and ascertain brake motion when electric Source is cut during motion.
-Limit switch motion test under hoist-up hoist-down without load and ascertain limit switch motion at upper and lower limit.

(e) Voltage and Ampere Measurement
-No-load and sling rated load and 125% load, hoist up and down, and measure amperes at rated voltage.

(f) Insulation Resistance Measurement
-By using 500V megger, measure insulation between the wiring of partitioned circuit and ground.

(g) Parts Inspection
-Hook; Ultrasonic or magnetic particle inspection is made
-Electrical parts; International test standards are applicable.

(h) Materials Test and Inspection
-The records of material analysis and mechanical test of materials, such as main beam, rail, hook, drum, transmission shaft other parts, based on international accepted test standards executed by material makers are ascertained.
-All of the document provided by manufacture shall be signed by an authorized person and organization.

(f) Dimension Inspection
-Span, head, hook approach, hook lift, traversing rail span, crane height on travelling rail surface, total length of main beam, others.
-Girder, saddle, trolley, walkway, ladder-cabin, high and space of opening on the crane, handrail on the crane, maintenance step ladder, etc.

(i) Paint Inspection
-Main pump test and inspection methods applied.
-Girder, saddle, trolley, walkway, ladder-cabin, high and space of opening on the crane, handrail on the crane, maintenance step ladder, etc.

14.1.5.6 Compressors and Blowers

Tests shall be carried out in accordance with the relevant international standard. All compressors and blowers shall be tested with their ancillaries to confirm design performance, particularly in respect of flow and pressure. The test shall demonstrate that vibration and noise are within the specified limits and that the pressure relief valve operates correctly.

Air receiver shall be tested in accordance with the relevant section of B.S. 5169.

All pressure vessels shall be inspected, and hydro water tightness tested. Test will be conducted with Job Motors at Compressors/Blowers manufactures place

14.1.5.7 Process Plant Items

All process plant items shall be tested to ensure they meet the Employer's Requirements for quality of workmanship, construction, and performance at the place desired by the client.

14.1.5.8 Sluice Gates& Weir Gates

(a) Seat Clearance Check

With the gate fully closed, the clearance between seating faces when checked with the filler gauge, shall not exceed 0.1 mm.

(b) Movement Tests

Each gate shall be operated Manually/Electrically three times from the fully open position to the Fully closed position and return to fully open, under no flow conditions to demonstrate that the Assembly is workable.

(c) Leakage Tests

With the gate in closed position, design pressure shall be applied for a period not lesser than 5minutes. To the unseating side of the sluice gate and the leakage shall not exceed the maximum leakage Permissible as per IS 13349.

(d) Hydrostatic Tests

Finally, a differential of one and a half times the design pressure shall be applied to the unseating side of the gate. Under these tests no part shall show any deflection of deformation.

14.1.5.9 Medium and Fine Screens

(a) All screens shall be checked for overall dimensions, assembly and clearance between the bars / space between a rake and bar surface / aperture size and its material as well as painting works. Moreover, motion of rake/drum and wiper/self-cleaning arrangement shall also be tested at works.

(b) Conveyor shall be checked for dimensions and physical conditions, belt joint portion, travelling accuracy of belt, motors and its power consumption, performance of safety device.

(c) At least one screen of each type shall be tested for efficiency and operation by employing screenings. For the screen having depth of channel more than 3 metres, testing with reduced depth is acceptable.

14.1.5.10 Pressure vessel

The inspection and testing shall be conducted as per approved procedures

The following tests shall be carried out, but not limited to:

(a) Specification and Quantity Inspection.

(b) Appearance Inspection.
-Visually check the tank surface and weld bead, bevelling, others
- (dent, surface scratch & weld flash, joint at right angle)
-Dimension inspection (distortion, misalignment, total length, diameter, other)
-Welding condition of pipe and flange
-Gaskets surface and number of bolt hole

(c) Hydrostatic Test
Test pressure and duration for hydrostatic test of surge tank, pipe and fittings, valves shall be as per the test pressure and test duration specified in relevant standards.

(d) Material Identification
-Mechanical test of materials based on internationally accepted standards executed by maker with material test certificates
-Tank, flanges, welding rod
-Gasket and bolts and nuts
-Coating

(e) Welder Qualification Test

(f) Welding Test; Radiography, UT, PT, MT as applicable

(h) Dimension Inspection

The following dimension are measured based on the approval drawings and ascertained.
-Vessel tank; Diameter, thickness, total length, tank head, support and its welded angle.
-Pipe: Outer dimensions, thickness, roundness, degree of bend, length, no proper connection between and equipment
-Flange diameter, thickness,
-Gasket thickness, bolt hole dimension

(h) Paint Inspection
-Main pump test and inspection methods applied

(i) Stage / in process inspection
Pressure vessel shall be hydrostatically tested as per requirement of IS 2825, in presence of Employer. For other tests specified, the certificates and shop records shall be duly approved and certified by the manufacturer and these shall be subject to review & approval by Employer.

14.1.5.11 Chlorine package

All items of plant shall be tested at manufacturer's works and test certificates shall be provided.
All chlorine gas piping from chlorine drums to chlorinator shall be pressure tested with dry air/nitrogen to a pressure of 15 kg/sq.cm.

The chlorine gas piping from the chlorinator up to injectors shall be pressure/vacuum tested with dry air/nitrogen to a pressure/vacuum equal to 1.5 times the maximum pressure/vacuum to be encountered during operation.

The motive water piping shall be hydrostatically tested for a pressure of 1.5 times the operating pressure or the maximum pump discharge pressure at pump shut off whichever is higher.

After the chlorine system has been completely tested as above, leak proof tests shall be conducted admitting chlorine gas. Leakages, if any, shall be identified using an ammonia stick. During this test all chlorine leak detectors shall be in place and all safety procedures shall be adhered to standard practice as per IS codes.

14.1.5.12 Ventilation system

The ventilation fans shall be tested at manufacturer's works to verify the design flow and pressure. Internal test certificates shall be furnished.

14.1.5.13 Fine Bubble Diffusers

(a) Clean water Standard Oxygen Transfer Efficiency (SOTE) tests shall be performed for each different diffuser grid geometry/arrangement proposed in the design, with at least 5% of the total diffusers to be tested. These tests shall be performed by the original diffuser Manufacturer at the Manufacturer's testing facility. The testing shall be performed in full compliance with the latest version of the applicable standard testing protocol. These tests shall be witnessed by Engineer as per procedures set forth for witnessing elsewhere in this document.

(b) All diffusers, including 5 % spares, shall be thoroughly inspected by the Contractor for physical damage to the membrane or any other part of the diffuser, and the results of the inspection shall be reported to the Engineer.

14.2 Field test

The test will verify the installation as well as the diffuser's ability to deliver the specified air flow rates at the manufacturer's stated pressure loss. Testing will also verify the uniformity of mixing provided.
Levelling tests:

1. Introduce clear water into each tank to the top of the diffuser elements.
2. Check the level of the diffusers to verify that all element horizontal surfaces are within 10 mm of a common horizontal plane and at the specified elevation.

Leakage and distribution of flow tests:

1. After successful completion of the levelling tests, raise the water level to 50mm above the manifold.
2. Visually inspect the water surface to ensure that the airflow is uniformly distributed across the tank.
3. Repair any leaks in the element holders, elements, pipes, or the like.
4. Repeat the test until the installation is essentially void of air leaks.

14.3 Reinforced Cement Concrete Pipes

Testing

(1) All pipes for testing purposes shall be selected at random from the stock of the manufacturer and shall be such as would not otherwise be rejected under the criteria of tolerances as mentioned in IS: 458.

(2) Contractor shall provide laboratory test /analysis results of cement and aggregate component and cement vs. aggregate vs. water mixing ratio and concrete mixing time and mixing method.

(3) During manufacture, tests on concrete shall be carried out as per IS:456. The manufacturer shall supply, when required to do so by the Engineer the results of compressive tests of concrete cubes and split tensile tests of concrete cylinders made from the concrete used for the pipes. The manufacturer shall supply cylinders or cubes for test purposes required by the Engineer and such cylinders or cubes shall withstand the tests prescribed as per IS:458. Every pressure pipe shall be tested by the manufacturer for the hydrostatic test pressure. For non-pressure pipes, 2 percent of the pipes shall be tested for hydrostatic test pressure.

(4) The specimen of pipes for the following tests shall be selected in accordance with relevant clause of IS: 458 and tests in accordance with the methods described in IS: 3597.

(1) Hydrostatic test
(2) Three edge bearing test
(3) Absorption test
(4) Dimension and colour of surface
(5) Damage

14.4 Sampling and Inspection

(1) In any consignment, all the pipes of same class and size and manufactured under similar conditions of production shall be grouped together to constitute a lot. The conformity of a lot to the requirements of this Employer's Requirements shall be ascertained on the basis of tests on pipes selected from it.

(2) The number of pipes to be selected from the lot for testing shall be in accordance with Table 15 of IS:458.

(3) Pipes shall be selected at random. In order to ensure randomness, all the pipes in the lot may be arranged in a serial order and starting from any pipe, every r-th pipe be selected till the requisite number is obtained, r being the integral part of N/n where N is the lot size and n is the sample size.

(4) All pipes selected shall be inspected for dimensional requirements, finish and deviation from straight. A pipe failing to satisfy one or more of these requirements shall be considered as defective.

(5) The number of pipes to be tested shall be in accordance with column 4 of Table 15 of IS:458. These pipes shall be selected from pipes that have satisfied the requirements mentioned in the above clause.

(6) A lot shall be considered as conforming to the requirements of IS:458 if the following conditions are satisfied.

(7) The number of defective pipes shall not be more than the permissible number given in column 3 of Table 15 of IS:458.

(8) All the pipes tested for various tests shall satisfy corresponding requirements of the tests.

(9) In case the number of pipes not satisfying requirements of any one or more tests, one or two further samples of same size shall be selected and tested for the test or tests in which the failure has occurred. All these pipes shall satisfy the corresponding requirements of the test.

(10) All destructively tested samples shall be replaced to new.

14.5 Steel Cylinders Pipes and Specials

Testing

a) Welding beat check Remove all scale on the welding points and welding beat and its thickness shall be checked by the Engineer.

b) Penetration Test
A suitable penetrating liquid (kerosene oil/Dye) is applied to the surface of the portion under examination and is permitted to remain there for sufficient time to allow the liquid to penetrate into any defects open at the surface. After the penetrating time, the excess penetrant, which remains on the surface, is removed. Then a light coloured powder absorbent called a developer is applied to the surface. This developer acts as a blotter and draws out a portion of the penetrant which had previously seeped into the surface openings. As the penetrant is drawn out it diffuses into the coating of the developer, forming indication of the surface discontinuities or flaws.

c) Each steel cylinder shall be subjected before lining/coating to a hydrostatic test under a water pressure equivalent to the test pressure in accordance with Clause 10 of IS:1916 and relevant provisions of IS:3597, provided that the whole of the area of the calculated reinforcement is used in the steel cylinder. In the case of pipes where a part of the principal reinforcement is provided in the cage, the steel cylinder shall be subjected to proportionately less hydrostatic test pressure.

d) Manufacturer's standard specials shall be hydrostatically tested before lining/coating. Where feasible, other specials shall be hydrostatically tested (before lining/coating) at factory. However, when this is not practicable, at the discretion of the Engineer, the unlined specials shall be tested by penetration test as per IS:3658 or other approved means.

e) The Contractor has to submit QA/QC and methodology for welding works

f) Approval of welding rods

g) Welders' qualification Test

14.6 Cast Iron / Ductile Iron Pipes

Mechanical Tests

Mechanical chemical tests shall be carried out during manufacture of pipes and fittings as specified in relevant IS codes. The results so obtained shall be considered to represent all the pipes and fittings of

different sizes manufactured during that period and the same shall be submitted to the Engineer. The method for tensile tests and the minimum tensile strength requirement for pipes and fittings shall be as per relevant IS codes.

Brinell hardness Test

For checking the Brinell hardness, the test shall be carried out on the test ring or bars cut from the pipes used for the ring test and tensile test in accordance with IS 1500.

Retests

If any test piece representing a lot fails in the first instance, two additional tests shall be made on test pieces selected from two other pipes from the same lot. If both the test results satisfy the specified requirements, the lot shall be accepted. Should either of these additional test pieces fail to pass the test, the lot shall be liable for rejection.

Hydrostatic test

For hydrostatic test at works, the pipes and fittings shall be kept under test pressure as specified in relevant IS codes they may be struck moderately with a 700 g hammer. They shall withstand the pressure test without showing any leakage, sweating or other defect of any kind. The hydrostatic test shall be conducted before coating the pipes and fittings.

14.7 Chlorination and Gas pipeline system

(a) All items of plant shall be tested at manufacturer's works and test certificates shall be provided.

(b) All chlorine gas piping from chlorine drums to chlorinator shall be pressure tested with dry air/nitrogen to a pressure of 15 kg/sq.cm.

(c) The chlorine gas piping from the chlorinators up to injectors shall be pressure/vacuum tested with dry air/nitrogen to a pressure/vacuum equal to 1.5 times the maximum pressure/vacuum to be encountered during operation.

(d) The motive water piping shall be hydrostatically tested for a pressure of 1.5 times the operating pressure or the maximum pump discharge pressure at pump shut off whichever is higher.

(e) After the chlorine system has been completely tested as above leak tests shall be conducted admitting chlorine gas. Leakages if any shall be identified using ammonia stick. During this test all chlorine leak detectors shall be in place and all safety procedures shall be adhered to.

(f) Gas cylinder shall provide the pressure test certificate issued by authority and manufacture year.

(g) Chlorine gas detector sensors shall be tested, and results shall provide to the Engineer.

(h) Ventilation system :
The ventilation fans shall be tested at manufacturer's works to verify the design flow and Pressure.

(i) Process Plant Items;

All process plant items shall be tested to ensure they meet the Employer’s Requirements for inlet and Outlet quality of workmanship, construction and system performance.

14.8 Mechanical equipment

All mechanical equipment shall be tested at site as following items in below:

(a) The test will be verified any damage/missing part, No. of equipment to be installed, material, location as specified in drawing, levelling, centreline, solid installation and condition of installation to be fit in levelling of pipeline and valves.

(b) Testing run will be conducted for verifying rotation direction, vibration, noise, and stability and any leakage, if possible.

(c) The test will be verified to check maintenance space and ease of equipment maintenance work.

(d) The testing shall be performed in full compliance with the latest version of the applicable standard testing protocol. These tests shall be witnessed by Engineer per procedures set forth for witnessing elsewhere in this document.

14.9 Tests at site

(a) In addition to the progressive supervision and inspection by Engineer, the Contractor shall offer for inspection to Engineer, the completely erected plant/part of Plant on which tests are to be carried out. After such inspection, each equipment/sub-system shall be tested by the Contractor in accordance with the applicable standards in the presence of Engineer. Such tests shall include but not be limited to the tests specified in following clauses.

(b) The Contractor shall possess during the entire working period the Electrical Contractor's licence of appropriate class from the concerned statutory authorities governing the area of work place. The Contractor shall fully comply with the relevant statutory rules and regulations. On completion of the installation or at intermediate stages, if required by the statutory authorities, the Contractor shall arrange for inspection and obtain the approval from the concerned statutory authorities. If any fees are to be paid to statutory authorities for testing, inspection and calibration these shall be paid by the Contractor and shall be included in his erection and commissioning charges.

14.10 Pumps, piping and valves

(a) The erected pipe work shall be subjected to a hydraulic test at 1.5 times the maximum pressure or twice the working pressure whichever is higher to test the soundness of the joints. Provision of the necessary pumps, gauges, blank flanges, tapping etc. for carrying out these tests shall be included in the Contract. All gas piping shall be air tested to twice normal working pressure.

(b) Leakage tests shall be carried out on all erected pipe work, pumps and valves immediately after erection and where possible before being built in.

(c) Operating tests shall be conducted on valves.

(d) The pump set shall be tested for satisfactory operation. The vibration and noise level shall be checked to be within the specified limits.

14.11 Motors

Condition of winding insulation be tested and insulation values shall be restored to required level by suitable heating arrangements locally.

14.12 Cranes

The crane and lifting tackle shall be tested to 125 % of the safe working load. The Contractor shall arrange the test load. The Contractor shall also arrange for the appropriate certificates from the concerned authorities before regular use of the cranes and other lifting equipment.

14.13 Screens

After erection, all screens shall be tested for smooth operation and capability to handle typical wastewater solids including stringy materials. Clearance between the dead plate and tines shall be checked as applicable.

14.14 Gates

(a) Leakage test shall be performed by the Contractor after installation of all Gates.

(b) Under the design seating head and unseating head the leakage shall not exceed the limit specified in IS:13349, for shop testing.

14.15 Reinforced Cement Concrete Pipes

(a) After laying and jointing of RCC pipes is completed the pipeline shall be washed out with sufficient water and be tested at work site as per the Employer's Requirements and as directed by the Engineer. All equipment for testing at work site shall be supplied and erected by Contractor. Water for testing of pipes shall be arranged by him. Damage during testing shall be Contractor's responsibility and shall be rectified by him to full satisfaction of the Engineer. Water used for the test shall be removed from pipes and not released to the excavated trenches.

(b) After the joints have thoroughly set and have been checked by the Engineer and before back filling the trenches, the entire section of the sewer shall be proved by the Contractor to be water tight by filling in pipes with water to the level of 1.50m above the top of the highest pipe in the stretch and heading the water up for a period of one hour.

(c) The apparatus used for the purpose of testing shall be approved by the Engineer. Contractor if required by the Engineer shall dewater the excavated pit and keep it dry during the period of testing. The loss of water over a period of 30 minutes should be measured by adding water from a measuring vessel at regular 10 minutes intervals and noting the quantity required to maintain the original water level. For the approval of this test the average quantity added should not exceed 1 litre/ hour/100 linear metres / 10mm of nominal internal diameter. Any leakage including excessive sweating which causes a drop in the test water level will be visible and the defective part of the work should be removed and made good.

(d) In case of pressure pipeline, the completed stretch of pipeline shall be tested for site test pressure. The site test pressure should not be less than the maximum operating pressure plus the calculated surge pressure, but in no case should it exceed the hydrostatic test pressure as specified in IS: 458.

14.16 Steel Cylinder Pipes and Specials

(a) After laying and jointing of steel cylinder pipes and specials with concrete lining and coating is completed the pipeline shall be washed with sufficient water and be tested at work site as per the following Employer's Requirements and as directed by the Engineer. All equipment for testing at work site shall be supplied and erected by Contractor. Water for testing of pipes shall be arranged by him. Damage during testing shall be Contractor's responsibility and shall be rectified by him to the full satisfaction of the Engineer. Water used for test shall be removed from pipes and not released to the excavated trenches.

(b) Each section of the pipe line shall be slowly filled with clean water and all air shall be expelled from the pipeline. The pressure in the pipeline should then be raised and maintained by means of pump to the test pressure. The test pressure should not be less than 1 1/2 times the working pressure at the lowest point or the static head pressure, whichever is higher. Under the test pressure no leak or sweating shall be visible at the welded joints. The duration of test shall be not less than 24 hours. The exposed joints shall be carefully examined and all such joints showing visible leaks shall be re-welded. Any cracked or defective pipes and specials in consequences of this pressure test shall be removed and replaced by sound material by Contractor and the test shall be repeated to the satisfaction of the Engineer.

(c) Hydrostatic shop test for pipes and fittings shall be as per code/standard requirement. After erection at site, complete pipes and fittings shall be hydrostatically tested for a pressure of 1.5 times operating pressure.

(d) Where directed by the Engineer welded joints on pipes larger than 675 mm diameter shall be subject to a nitrogen gas test after welding.

(e) A tapped hole (approximately 6 mm diameter) shall be made in the socket end of each pipe by the Contractor and shall be fitted with a suitable non-return valve. Nitrogen, at 400 kpa pressure, shall then be pumped into the annular space between the spigot and socket and the pump disconnected.

(f) If no drop in pressure occurs over the ensuing period of 30 minutes the test shall be deemed to be successful. If the test pressure cannot be maintained for 30 minutes all defects in the weld shall be cut back and re-welded and the test reapplied until successful. The cost of initial and subsequent testing of defective welds shall be at the Contractor's own expense.

(g) The Contractor shall provide all items necessary for the nitrogen tests including compressor, valves, gauges and tubing.

14.17 Cast Iron, Ductile Iron Pipes and Fittings

(a) After the pipes and fittings are laid, jointed and the trench partially backfilled except at the joints the stretch of pipe line as directed by Engineer shall be subjected to pressure test and leakage test after washing the pipe line out with sufficient water.

Where any section of the pipeline is provided with concrete thrust blocks or anchorages, the pressure test shall not be made until at least five days have elapsed after the concrete was cast. If rapid hardening cement has been used in these blocks or anchorages, the tests shall not be made until at-least two days have elapsed.

(b) Each section of the pipe line shall be slowly filled with water and all air shall be expelled from the pipe by tapping at points of highest elevation before the test is made and plugs inserted after the tests have been completed. The specified test pressure based on the elevation of the lowest point of the line or section under test and corrected to the elevation of the test gauge shall be applied by means of a pump connected to the pipe as directed by the Engineer.

(c) The duration of test shall not be less than 5 minutes. The exposed joint shall be carefully examined and all such joints showing visible leaks shall be re-caulked until water tight. Any cracked or defective pipes and fittings in consequence of this pressure test shall be removed and replaced by sound material by Contractor at no extra cost to the Engineer and the test shall be repeated to the satisfaction of the Engineer.

(d) After the satisfactory completion of pressure test, the section of pipeline shall be subjected to leakage test. The duration of test shall be 2 hours. No pipe installation shall be accepted until the leakage is less than the number of cm^3/h as determined by the formula:

$$q_L = \frac{ND\sqrt{P}}{3.3}$$

Where,

q_L = The allowable leakage in cm^3/hr

N = Number of joints in the length of the pipeline

D = Diameter in mm, and

P = The average test pressure during the leakage test in Kg/cm^2

Should any test of pipe laid indicate leakage greater than that specified above, the defective joints shall be repaired by Contractor at no extra cost to the Engineer until the leakage is within the specified allowance.

(e) Necessary equipment and water used for testing shall be arranged by Contractor at his own cost. Damage during testing shall be Contractor's responsibility and shall be rectified by him at no extra cost to the Engineer. Water used for testing shall be removed from the pipe and not released in the excavated trenches.

(f) After the tests mentioned above are completed to the satisfaction of the Engineer, the backfilling of trenches shall be done as per the Employer’s Requirements specified elsewhere.

14.18 Manufacturer's Works Acceptance Tests on Electrical Equipment

The following equipment / items shall be subjected to inspection, routine /acceptance tests as per latest edition of relevant Indian / International standards in the presence of Employer/ his Engineer.

(a) 11/0.433kV Distribution Transformers
(b) 11kV Metal enclosed Switchgears.
(c) 415V Metal enclosed switchgears (PCC / DG PCC / PMCC/ MCC)
(d) 415V Distribution Boards (MLDB, Emergency PDB, Valve DB, Lighting DB, Fan DB etc.)
(e) 415V Power capacitor and control panel (APFC)
(f) Diesel Standby Generator with AMF Control Panel
(g) Battery, battery charger and DC Distribution Board
(h) Variable Frequency Drives
(i) Soft Starters
(j) Non-Segregated Bus Duct
(k) Power & control cables

(l) Lighting System
(m) Earthing and lightning protection systems
(n) Local Control Panels (LCP)
(o) Junction Boxes
(p) Cable Carrier System
(q) Solar PV system for street lighting or any other application.

Copies of test Certificates for the type tests and Special tests not later than 5 years conducted as per relevant Indian / International Standards for all the equipment /items of above shall be furnished for the perusal of Employer / his Engineer. If type tests and special tests have not been conducted on any of these items, the same shall be carried out in the presence of owner/ Engineer at no extra cost.

14.19 Inspection & Testing requirements for ICA works

Inspection & Testing Requirements for Instrumentation, Control and Automation equipment, other related equipment as required under specifications:

A. Inspection and Testing Requirements for Instrumentation works

1. Inspection, Testing and Setting to Work — General

Each item of plant shall be subjected to the manufacturer's own tests which shall be certified. Each item of plant and its installation shall be subject to inspection and testing at the place of manufacture. The Contractor shall be responsible for the provision of all necessary test equipment. The Contractor shall demonstrate to the Engineer, the correct operation of any item of plant and the Engineer may witness any test. Tests which, in the opinion of the Engineer, were failed or not performed correctly shall be repeated.

Before any test is made, the Contractor shall submit to the Engineer a full list of test equipment to be used. Each item of test equipment shall have a standard of accuracy better than that stated by the manufacturer of the item to be tested. The Contractor shall provide evidence of the condition and performance of any item of test equipment, in the form of test certificates issued by an appropriate authority independent of the Contractor and manufacturer, or as otherwise directed by the Engineer. Test equipment shall be checked frequently during the period of the tests.

The Contractor's staff responsible for supervising and carrying out tests shall be fully conversant with the various items of equipment of other manufacturers and if necessary the Contractor shall arrange for his personnel to attend suitable training courses on his own expense. The Contractor has to get approval from the client's representative for the training personnel to be employed by the Contractor.

Any fault or shortcoming found during any inspection or test shall be rectified to the satisfaction of the Engineer before proceeding with further inspection or testing of that item. Any circuit previously tested, which may have been affected by the rectification work, shall be re-tested.

2. Preliminary Inspection and Testing at the Place of Manufacture

Field Instruments and Analytical Instruments

After the successful completion of the manufacturer's own inspection and testing of instruments to be supplied under the Contract, complete functional tests inclusive of calibration checks shall be carried out in the presence of the Engineer, engineer's representative and the Contractor at the manufacturer's factory where the instruments have been manufactured. Such tests shall include a demonstration that an

increase or decrease of the measured value at several points over the full range of the instrument produces a corresponding increase or decrease in the instrument output signal. These tests shall include checks on the specified accuracy of the instrument at all points. Complete functional testing of all instruments (Field instrumentation inclusive of all Analytical instrumentation, lab equipment & LIMS system, Online Real Time Multi Parameters Continuous Monitoring System for Influent and Treated Sewage Parameters, Auto samplers, LED screen display system, wireless communication equipment, etc, covering all instruments and related equipment (Junction box, local control panels, all cables, cable trays)

3. Instrument panels, enclosures and mounting boards

The manufacturer shall not present instrument panels, enclosures, junction boxes and mounting boards (assemblies) for inspection and testing until the manufacturer's own tests and inspection has been completed. A preliminary inspection and test of these assemblies shall then be witnessed by the Engineer, engineer's representative. The Contractor shall give not less than 15 days' notice in writing that he has completed his tests and inspection and is ready for the witnessed tests and inspection. Where this notice period is different in the Conditions of Contract this shall take precedent.

The witnessed inspection and testing shall include the following on a minimum:

a. Complete functional testing of the instrument inclusive of calibration and sampling system (applicable for all field and analytical instruments, Online Real Time Multi Parameters Continuous Monitoring System for Influent and Treated Sewage Parameters, Auto samplers):
b. A visual inspection of the panel assembly to show that the design, construction and finish are satisfactory and in accordance with the Specification;
c. A check that equipment is securely mounted, accessible for removal or calibration without damage to or undue disturbance of other components, wiring or piping;
d. That all engraving and labels are correctly positioned, fixed and designated in accordance with the Specification;
e. Panel power-distribution circuits have the correct breaker/fuse rating coordination and designation;
f. Power-isolation facilities meet the Specification;
g. The main incoming supply voltage, frequency and/or pneumatic supply pressure is within the required limits, these being checked at the beginning and end of the test and the results recorded on test certificates;
h. The output of all power supply units again at the beginning and end of the testing with results being recorded;
i. The power supply voltage or air pressure of all component instruments of the assembly(s), these voltages/pressures being recorded on the test certificate;
j. The insulation resistance of all circuits except sensitive electronic equipment which is liable to damage by application of the test voltage, such circuits being disconnected before making the insulation resistance tests and these tests being carried out in accordance with IEE Wiring Regulations;
k. That the clean earth bar is isolated from main frame of the panel. Internal lighting and anti-condensation heaters and associated thermostats, isolators, limit switches and wiring shall be checked for compliance with the Specification. Spare capacity within the panel(s) shall be checked to see that it complies with the Specification. This shall include future equipment space, spare terminals, space in wiring trunking and provision for additional cable entry.

4. Functional Testing at the OEM factory where the equipment has been manufactured

General requirements

Once the preliminary inspection and testing is complete to the satisfaction of the Engineer, functional testing shall commence in the presence of the employer and employer's representative for 100% quantity of all equipment. The purpose of the functional tests are to demonstrate that all instruments and analytical instruments, lab equipment & LIMS system, Online Real Time Multi Parameters Continuous Monitoring System for Influent and Treated Sewage Parameters, Auto samplers, LED screen display system, wireless communication equipment, etc, covering all instruments and related equipment (Junction box, local control panels, all cables, cable trays), panels' enclosures and mounting boards (assemblies),sampling system conform to requirements of the Specification. Functional testing on a minimum shall include, calibration check as per established international standards, transmitter function check, error reporting, alarm functions, communication check with external third party devices, etc.

Not less than 30 days before the commencement of functional tests, the Contractor shall submit to the Engineer, for approval, two copies of comprehensive test procedural documents detailing each test to be carried out. The document shall include results forms on which the results of each test will be entered. The forms shall include spaces for numerical values, where necessary, and witness signatures. All applicable drawings and data shall be provided at the place of inspection by the Contractor.

The Contractor shall provide all test instruments and equipment necessary to test the assemblies in their entirety.

The following is a typical list of the equipment required:
• Switch boxes;
• Indicator light boxes;
• Analogue signal sources;
• Dummy loads;
• Meters;
• Simulators;
• Desk-top computers;
• Programmers for PLC or outstations;
• Insulation test equipment.

5. Quality Assurance/Quality Control (QA/QC/QAP)

QA/QC shall comply with the Contract, with particular requirements specific to the equipment or service being provided as outlined below for ICA system and in full compliance to clause 16.35, sub clause-1,2,3 & 4, as detailed in above specifications. The quality assurance/control procedures shall include, but not be limited to the following:

- Continuity and Wiring tests;
- Calibration check:
- complete functional testing of equipment along with sampling system(as applicable):
- Insulation and High Potential Testing;
- Packaging and Shipping;
- Welding;
- Cleaning and Painting.

The quality assurance/quality control documentation shall include, but not be limited to the following:

- Material Certifications;
- Shop Test Reports;

All other documentation required by applicable codes and standards.

B. Inspection and Testing Requirements for Control &Automation works

a) Factory Acceptance Test (FAT)

The Contractor shall conduct a full programme of tests of the PLC & SCADA system at the Contractor's testing facility in the presence of the Engineer to verify that all features of the system have been provided, are operating correctly and are in full compliance with the Specification. Unless otherwise specified or agreed by the Engineer, the entire PLC & SCADA system shall be assembled and tested together as an integrated system, including all master station equipment, all operators' consoles, all outstations and telemetry equipment all instrumentation panels and uninterruptible power supplies included in this Specification. The scheduled date for the factory acceptance test shall be as agreed by the Contractor and the Engineer at least four weeks before the test.

The PLC and SCADA system shall be conducted as one complete system FAT only. No separate FAT for PLC and separate FAT for SCADA system shall be conducted. Contractor to note the importance of this clause. The Contractor shall submit the Factory Acceptance Test (FAT) Procedure which is in line with the approved control philosophy as well as P&IDs including Original Equipment Manufacturers (OEMs) test procedures with Inspection Formats (Including SCADA Screens) and also to Obtain approval on FAT procedure prior to release of any inspection call letter.

Not less than one month before the scheduled factory acceptance test, the Contractor shall submit to the Engineer for approval two copies of a comprehensive manual detailing each test to be conducted. The manual shall include a results form on which the results of each test will be entered, including spaces for numerical values where appropriate and witness signatures.

Not less than 21 days before the scheduled factory acceptance test, the Contractor shall submit the internal completed FAT test reports to the Engineer as per contract requirements, which has been witnessed and signed by the Contractor representative and that, in the opinion of the Contractor, the system exhibits stable operation and is ready for the formal factory acceptance test by the employer and the employer's representative.

The factory acceptance test will be considered successfully completed only when the system has successfully passed all factory tests as detailed in the FAT procedure and Functional design specifications. The system shall not be delivered to Site until the successful completion of the factory acceptance test is certified by the Engineer. Delay in the delivery of the system due to failure of the factory acceptance test shall not constitute an unavoidable delay. If the system fails the factory acceptance test, the test shall be extended or rescheduled at the discretion of the Engineer.

All hardware to be used in the testing of the system shall have passed an agreed preliminary hardware performance test to ensure known hardware operability before software testing begins.

After successful completion of the factory acceptance test, no software changes shall be made to the system without written authorisation by the Engineer. Any changes to the system which effect the system software documentation, such as input scale modifications or changes to the control logic, shall be entered into the system documentation before delivery of the system to Site.

The entire cost of the complete FAT and any other required testing(interoperability, site visits etc..), including reasonable per diem expenses to cover meals, lodging, transport and similar expenses for all BWSSB& employers representative personnel attending the tests, shall be the responsibility of the Contractor/ system supplier and shall be included in the contract price.

b) Factory Acceptance Test Procedures (FAT)

The Contractor has to obtain & submit the check list (included with internal Test Reports) from the concerned Original Equipment Manufacturer (OEM) prior to planning on FAT.

Factory Acceptance Test (FAT) Check List:

S. No.	Type of Tests	Yes / No (Y/N)	OEM standard test format
A.	Hardware Tests		
i)	Power-up test (includes Redundancy feature on power supply modules)	Y	As per OEM Test Format
ii)	CPUs Test (Cold Run & Hot Run)	Y	As per OEM Test Format
iii)	Hot-Stand by Test on Master PLCs	Y	As per OEM Test Format
iv)	Hardwired Simulation test on each RIO module (DI, DO, AI & AO)	Y	As per OEM Test Format
v)	Hot swappable IOs	Y	As per OEM Test Format
vi)	Communication Redundancy on each node of RIOs (includes Ethernet Switches with hardwired communication cables between Plant PLC panel and each RIO panel)	Y	As per OEM Test Format
vii)	CPU memory demonstration test (Spare memory, Assigned memory)	Y	As per OEM Test Format
viii)	Master PLC & RIO modules insulation test (includes Grounding)	Y	As per OEM Test Format
ix)	Hardware Diagnostic tests (Fault Diagnosis on Power Supply modules, Controllers, RIO modules, Ethernet Switches, Wireless Gateways and HART protocol filed Instruments)	Y	As per OEM Test Format
B.	Software cum Functionality Tests		
i)	SCADA Screens (To verify as per approved P&IDs including color code animation tests with simulator)	Y	As per OEM Test Format
ii)	SCADA Screens Run Time (individual cum MIMIC Screens refresh rate period on process variables with feedback & command signals also to demonstrate IO tags updation for addition / deletion)	Y	As per OEM Test Format
iii)	Communication establishment between Master PLCs, RIOs & Vendor Package Controllers	Y	As per OEM Test Format
iv)	IO Tag numbers (Including spare Tags for future expansion utilization)	Y	As per OEM Test Format
v)	Assignment of Set-point values (for each process variable cum Timers etc.. for the periods of FAT and SAT)	Y	As per OEM Test Format
vi)	Simulator tests on final control elements and field process variables (Interface between PLC & SCADA system)	Y	As per OEM Test Format
vii)	Sequence of operations cum Interlocks with Alarms on each sub process system of STP (As per approved control philosophy document)	Y	As per OEM Test Format

S. No.	Type of Tests	Yes / No (Y/N)	OEM standard test format
viii)	Reports & Trend displays on SCADA system (selection of particular process variable or final control element status on the basis of daily, weekly, monthly & yearly)	Y	As per OEM Test Format
xi)	Historian Data Test (including interface between SCADA & Historian systems)	Y	As per OEM Test Format
xi)	Tests Pass or Failure Summary Sheet [Software cum Functionality test failure & pass cases (As per above tests) are to be recorded during Factory Acceptance Test MOM]	Y	As per OEM Test Format
C.	Reliability Test [Continuation of functionality test till 48-hours' time with tested Results	Y	As per OEM Test Format
D.	FAT Documentation [All above test Results (as Passed / Failed) are to be documented & submitted to the competent authorities for obtaining dispatch clearance]	Y	As per OEM Test Format

1) General

The scope of the tests shall include the proving of every aspect of hardware and software operation and functions as detailed below.

2) Hardware tests

(a) Verify the correct inventory of hardware including cables and printed circuit boards;
(b) Demonstrate that all spare-memory, disk-capacity and system-expansion requirements have been met;
(c) Demonstrate all hardware and software diagnostics;
(d) Verify all power supply voltages are within tolerance;
(e) Verify proper earth connections and isolation of instrumentation earth for all equipment;
(f) Demonstrate operation of test simulation and indication equipment and its Suitability for adequate functional testing of all system functions.

3) Software tests

(a) Demonstrate the editing of all system parameters including set-points, timers and the like;
(b) Demonstrate system configuration capabilities including the addition and deletion of input and output points, outstations, and all data base parameters;
(c) Demonstrate the addition, deletion and modification of mimic displays and report & Trend formats;
(d) Complete control philosophy with all interlocks shall be demonstrated
(e) Historian data check.

4) Functional tests

The functional tests shall verify proper operation of every specified system function as an integrated system. These tests shall be conducted in conjunction with functional tests of instrumentation and control panels as specified elsewhere. All failures or discrepancies found shall be documented in the test manual.

Following a failure of any functional test, should software or hardware modifications be required it shall be the decision of the Engineer whether the factory acceptance test is to continue, re-start or be aborted. If testing is allowed to continue, any changes which are required shall be described in a system modification document, signed by both Contractor and Engineer and be incorporated into the final factory acceptance test documentation. The failed test shall be re-conducted and the Engineer may require the retest of functions which may be affected by the modification.
The functional tests shall include, as a minimum, the following:

(a) Demonstration that the system meets the requirements of the Specification for response time and speed of screen update;
(b) Verification of the accuracy of all analogue input points in the system. The procedure shall include applying the appropriate signal to each analogue input at a minimum of three points within the range of the input, checking for expected numerical results, and verifying appropriate update of related mimic displays. Proper sensing and action by the system to high and low out-of-range inputs shall also be verified;
(c) Verification of the proper logic sense, pulse accumulation and rate computation where appropriate, of all digital inputs and verifying appropriate update of related mimic displays;
(e) Verification of all control and sequencing operations and proper operation of all digital and analogue outputs. The procedure shall include simulation of all related process variables for both normal and abnormal conditions, including instrument and component failure, and demonstration of fail-safe response of the system. System outputs shall be indicated with appropriate lamps and indicators;
(f) Simulation of outstation communications errors and failures and demonstration of error detection and handling, failure detection and handling, and appropriate changes to control actions as designed and specified;
(g) Verification of fault detection and diagnostics by inducing a sufficient variety of fault conditions in the system to ensure that detection processes and fail-safe operation are adequately tested;
(h) Demonstration of proper operation of all mimic displays, help pages, reports, operator procedures and historical data accumulation;
(j) Demonstration of proper operation of all outstations following a simulated master station central processor failure;
(k) Demonstration of proper operation of all equipment during both a system wide or isolated power failure, and following power restoration. The procedure shall include the demonstration of battery backup of both master station and outstation for the full length of time specified, and proper operation of power fail, low voltage warning and all associated alarms.

5) Reliability test

After successful completion of the functional tests a 48-hour continuous run of the system shall be performed. The test shall be passed if no system function is lost or no hardware or software failure occurs. Hardware failure is defined for this test as the loss of a major component such as the computer, an outstation, a VDU or a peripheral device. Non-repetitive mechanical failures of loggers, push-buttons and the like are excluded.

During this test, the system shall be exercised with simulated inputs and conditions in a manner which approximates the on-site operational environment. Unstructured testing by the Engineer shall be included during this test. Upon any system failure during this period, it shall be the decision of the Engineer whether the reliability test is to continue or be aborted. If testing is allowed to continue any changes to the system which are required shall be described in a system-modification document, signed by both Contractor and Engineer and the document shall be incorporated into the final factory acceptance test documentation.

c) Factory acceptance test documentation

As a minimum, the following information shall be included in the factory Acceptance test manual for each test:
• Test identification number;
• Test name and description;
• List of all equipment to be tested including any special test equipment required;
• Description of the test procedure broken down into logical steps, complete control philosophy check;
• Description of the expected system response verifying the completion of each logical step;
• Space for recording the results of the test and the time and date of the test;
• Space for signatures of the Contractor and the Engineer.
In addition, the Contractor shall provide a method for recording and tracing all problems, discrepancies, queries and suggestions regarding the system and software, and for formalised control of any modifications to the system.

d) Pre-commissioning tests

The Contractor shall perform pre-commissioning, or preliminary, testing of the SCADA system in accordance with that specified for instrumentation. The purpose of pre-commissioning tests is to confirm readiness of the system for commissioning.

The scope of pre-commissioning tests shall be generally as specified for factory acceptance tests but real field inputs and final control elements shall be used wherever practical to provide inputs to the system and to confirm proper outputs.

Where this is impractical, simulation signals shall be injected as near as possible to their ultimate sources so as to include in the tests as much of the cabling system as possible.

Each process system shall be set to work under manual control and the system tested to confirm proper operation. After proper operation of manual control mode has been verified, tests of automatic controls of each process system shall be conducted wherever practical.

e) Site Acceptance Tests (SAT)

The Contractor shall submit all relevant draft operating manuals for the PLC & SCADA System to the Engineer for approval prior to commissioning tests. Any faults or failures of the system detected during the previous tests shall be noted and corrected to the satisfaction of the Engineer before commissioning is allowed to commence.

As part of commissioning the PLC & SCADA system(complete ICA system inclusive Field instrumentation , Analytical instrumentation, lab equipment & LIMS system, Online Real Time Multi Parameters Continuous Monitoring System for Influent and Treated Sewage Parameters, Auto samplers, LED screen display system, wireless communication equipment, etc, covering all instruments and related equipment (Junction box, local control panels,etc) shall be tested for availability for a continuous period of ninety days. The control and instrumentation system shall be subjected to SAT only after the complete plant electro-mechanical and ICA works have been completed and tested to perform as per contract requirements and both manual and auto mode of operations has been completely tested and found to be as per contract requirements. During this period, the system will perform the normal functions according to the procedures described in the SAT documentation approved by the Engineer.
The system shall have passed the SAT if all major components have been free from fault or failure and exhibit full error-free functionality for 100 % of the total duration of the test. Major components include

all master station equipment, outstations, communications facilities and instrument panel components, excluding push-buttons, switches and lamps and any equipment not supplied by the Contractor. If the system fails to meet the above criteria, the SAT period shall be reinitiated further for a period of thirty days, till such time the complete system exhibits full error-free functionality for 100 % of the total duration of the test.

During SAT, no modifications to the system shall be made by the Contractor without the written approval of the Engineer. Erroneous functioning which requires software modifications or re-configuration to correct, other than set-point or parameter changes, shall constitute a failure of the availability test. Any changes to the system which are required and approved shall be described in a system-modification document, signed by both Contractor and Engineer and the document shall be incorporated into the final test documentation. The test shall be restarted after corrections have been made.

14.20 Manufacturer's Works Acceptance Tests on Uninterruptible Power Supplies

The Contractor shall carry out further specified tests as follows in addition to any tests stated or implied by the foregoing sections of this clause.

The tests shall be carried out on the fully assembled unit utilising the batteries that are to be supplied with the unit.

The Contractor shall demonstrate the following:

(1) Change-over from full load with mains present to full load on battery supply
(2) Carry out a discharge test on the system at full load and for the specified duty bridging time period.
(3) Carry out recharge test after operation for the specified duty bridging time at full load. The UPS shall supply the full load during the recharge cycle.

14.21 Inspection at Site

During erection of the Plant the Engineer will inspect the installation from time to time in the presence of the Contractor's Supervisor to establish conformity with the requirements of the Specification. Any deviations found shall be corrected as instructed by the Engineer.

14.22 Plant protection on Site

Factory finished plant shall be adequately protected both before and during installation against damage to finished surfaces, fitted components, and the ingress of dust. It may be necessary for structural finishing operations to be carried out in the vicinity of installed plant before it is taken over and the Contractor shall take this into consideration in complying with the requirement of this clause.

14.23 Erection staff

The Contractor shall provide at least two approved senior English speaking working erectors to supervise the erection of all Plant in the Contract and in each case to act as the Contractor's Representative as set out in Clause 13 of the general conditions of contract.

In the case of a foreign firm based overseas the Contractor's Representative shall be thoroughly conversant with the manufacturer's Plant and equipment, and its erection and shall be an expatriate.

The Contractor shall also provide sufficient erectors skilled in electrical, mechanical and instrument engineering, with such skilled, semi-skilled and unskilled labor as are necessary to ensure completion of the various sections of the Contract in the time required. The Contractor shall not remove any supervisory staff or labor from the site without the prior approval of the Engineer.

The Engineer will give the Contractor at least one month's notice in writing of the date on which the erection staff will be required on site, and the Contractor shall confirm the date of arrival in writing to the Engineer. The Contractor shall make all the necessary arrangements to ensure that sufficient plant has been or is about to be delivered to site, so that there shall be no delay to the start of erection.

It shall be the responsibility of the Contractor to obtain necessary License / Authorization n/Permit for work from the Licensing Boards of the Locality/State where the work is to be carried out. The persons deputed by the Contractor's firm should also hold valid permits issued or recognized by the Licensing Board of the Locality/State where the work is to be carried out.

14.24 Erection and Building-in

The installation work shall comply with the latest applicable Standards, Regulations, Electricity Rules and act and Safety Codes of the locality where the installation is to be carried out. Nothing in this specification shall be construed to relieve the Contractor of this responsibility.

It will be the Contractor's responsibility to obtain approval/clearance from local statutory authorities including Electrical Inspector, wherever applicable for conducting of any work or for installation carried out which comes under the purview of such authorities.

The Contractor shall carry out the complete erection of all plant, including the provision of all necessary skilled and unskilled labor, material, transportation, supplies, power and fuel, Contractor's Equipment and appurtenances necessary, for the complete and satisfactory erection of the Plant.

The Contractor shall have a separate cleaning gang to clean all equipment under erection and as well as the work area and the project site at regular intervals to the satisfaction of the employer. In case the cleaning is not up to the employer's satisfaction, he will have the right to carry out the cleaning operations and any expenditure incurred by the employer in this regard will be to the Contractor's account.

Erectors

The Contractor's employees shall include skilled erection staff in sufficient number, who shall arrive on the site on or before the respective dates set out in the approved work programmed and prior to delivery of any item of Plant to the Site. The Engineer will not entertain any claim by the Contractor in respect of delayed erection due to a delay in the delivery of any items of Plant to the site.

Contractor's Equipment, materials and appurtenances

The Contractor shall have available on the Site sufficient suitable equipment and machinery, as well as all other materials and appurtenances required by him, of ample capacity to ensure the proper erection of Plant and to handle any emergencies such as may normally be expected in work of this character.

The Contractor shall be responsible if any installation materials are lost or damaged during installation. All damages and thefts of equipment/component parts, after takeover by the Contractor, till the

installation is taken over by Employer shall be made good by the Contractor to the satisfaction of Engineer.

Workmanship

Plant shall be erected in a neat and workmanlike manner on the foundation and at the locations and elevations shown on the approved drawings and other Engineering documents. Unless otherwise directed by the Engineer the Contractor shall adhere strictly to the aforesaid drawings and no departures there from will be permitted.

All plant shall be correctly aligned, leveled and adjusted for satisfactory operation and shall be installed so that the proper and satisfactory connection can be made readily between the various units and pipe work and equipment installed under the Contract. The mounting arrangements for pump sets and blowers shall be such that the alignment offset between motors and the driven equipment shall be well within 0.1 mm.

Building-in

Erection of Plant shall be phased in such a manner so as not to obstruct the work being done by other Contractors. Before commencing any erection work, the Contractor shall check the dimensions of structures where the various items of plant are to be installed, and shall bring any deviations from the required positions, lined or dimensions to the notice of the Engineer and shall take such measures as are necessary for their correction.

The Contractor shall take particular care for the correct positioning and alignment of all puddle pipes which are required through concrete structures prior to, and during the pouring of concrete.

The Contractor shall pin and plug in the holes prepared, all small clips, plugs, screws, nails, sleeves, inserts, etc., required for fixing electric wires and conduits, small pipe work and all other apparatus.

The Contractor shall align all equipment and holding down bolts and shall inform the Engineer before proceeding with grouting-in the item or item concerned. The Contractor shall ensure that all equipment is securely held and remain in correct alignment before, during and after grouting-in.

The Contractor shall properly bed in cement grout each item of plant or its supporting base resting on foundations and shall grout-in where required holding down bolts placed in the holes prepared in the foundations. The materials and workmanship used in grouting shall be such as will result in a solid anchoring of foundation bolts and complete filling of the gaps between the Plant or its base and the foundations, without shrinkage or cracking.

During erection of the Plant the Employer will inspect the installation from time to time in the presence of the Contractor's Site representative to establish conformity with the requirements of the Specification. Any deviations and deficiencies found, or evidence of unsatisfactory workmanship shall be corrected as instructed by the Employer.

All plant shall be installed in accordance with the recommendations or instructions of the manufacturer, for the application. Each mounting position shall be chosen to give correct operation of the equipment, ease of operation, access for maintenance and servicing and freedom from any condition which could have adverse effects.

In accordance with the specific installation instructions, as shown in Contractor's drawings or as directed by the Engineer's Representative the Contractor shall unload, erect, install, wire, test and place

into commercial use of all electrical equipment included in the contract. Equipment shall be installed in a neat, workmanlike manner so that it is level, plumb, square, and properly aligned and oriented.

The Contractor shall furnish all supervision, labour, tools, equipment, rigging materials and incidental materials such as bolts, wedges, anchors, concrete inserts etc. required to completely install, test and adjust the equipment.

Drawings, instructions and recommendations shall be correctly followed in handling, settling, testing and commissioning of all equipment and care shall be exercised in handling to avoid distortion to stationary structures, the marring of finish, or damaging of delicate instruments or other electrical parts.

The Contractor shall erect and commission the equipment as per the instructions of the Engineer's Representative and shall extend all co-operations to him.

In case of any doubt/misunderstanding as to correct interpretation of drawings or instructions, necessary clarification shall be obtained from the Engineer's Representative. The Contractor shall be held responsible for any damage to the equipment consequent to not following instructions correctly.

The Contractor shall move all equipment into the respective buildings through regular doors or floor openings provided specifically for the equipment. The Contractor shall make his own arrangement for lifting of equipment.

Where assemblies are supplied in more than one section, the Contractor shall make all necessary mechanical and electrical connections between sections including the connections between bus bars/wires. The Contractor shall also carry out the adjustments/alignments necessary for proper operation of the circuit breakers. All insulators and bushings shall be protected against damage during installation. Insulators or bushings chipped, cracked or damaged due to negligence or carelessness shall be replaced by the Contractor at his own expenses.

The Contractor shall take utmost care in handling instruments, relays and other delicate mechanisms. Wherever the instruments or relays are supplied separately, they shall be mounted only after the associated control panels have been erected and aligned. The blocking material/mechanism employed for the safe transit of the instruments and relays shall be removed after ensuring that the panels have been completely installed and no further movement of the same would be necessary. Any damage to relays and instruments shall be immediately reported to the Engineer's Representative.

The Contractor shall carry-out switchyard installation as required in the plan and elevation drawings of switchyard showing bus bar configurations, sizes, tensions, insulator details, etc.

The Contractor shall install complete set of bus bars and all bays, conductors, complete with tension/suspension insulator strings, bus-post insulators, equipment connections, bus bar connections to equipment, lightning shield wires including down comers. The down comers shall be brought up to a height of 1000 mm from ground level where they shall be connected to the test links.

Installation works of breakers and isolators with all accessories wherever applicable shall include adjustments/alignments necessary for proper operation of circuit breakers, isolators and their operating mechanisms. All insulators and bushings shall be protected against damage during installation. Insulators or bushings damaged due to negligence or carelessness of the Contractor shall be replaced by him at his expense.

Care shall be taken during handling of insulating oil to prevent ingress of moisture or foreign matter. In the testing, circulation, filtering, or otherwise handling of oil, rubber hose shall not be used. Circulation and filtering of oil, the heating of oil by regulated short-circuit current during drying runs and sampling and testing of oil shall be in accordance with the latest Code of Practice IS:10028.

Inspection, storage, installation, testing and commissioning of transformers shall be in accordance with the latest Indian Standards Code of Practice IS:10028. All commissioning tests as applicable, vide Appendix B of IS:10028 (Part II) shall be carried out.

Switchgear, relay and control panels shall be installed in accordance with the latest Indian Standard Code of Practice 10118. The switchgear panels shall be installed on finished surface or concrete or steel sills. The Contractor shall be required to install and align any channel sills which form part of the foundations. Tape or compound shall be applied where called for. The base of outdoor type units shall be sealed in an approved manner to prevent ingress of moisture.

All electrical installations shall be tested in accordance with the requirements provided in National Electrical Code, NEC SP:30-2023, Part I-General and Common Aspects, Section-17-Erection and pre-commissioning Testing of Installation.

After installation of all power and control wiring, the Contractor shall perform operating tests on all switchgear and panels to verify the proper operation of switchgear/panels and the correctness of the interconnections between various items of equipment. This shall be done by applying normal a-c or d-c voltage to the circuits and operating the equipment. Megger tests for insulation, polarity checks on the instrument transformers, operation tests on equipment, and installation tests shall be carried out by the Contractor who shall also make all necessary for proper functioning of the equipment.

Installation and testing of the battery and battery chargers shall be done in strict compliance with the applicable standards. Each cell shall be inspected for breakage and condition of cover seals as soon as received at site. The battery shall be set up on racks as soon as possible after receipt, utilising lifting devices. The cells shall not be lifted by the terminals. Contact surface of the battery terminals and intercell connectors shall be cleaned, coated with protective grease and assembled.

Each connection shall be properly tightened. Each cell shall be tested with a hydrometer and thermometer and the results logged. A freshening charge, if required, shall be added. When handed over to the Employer, the battery shall be fully charged, and the electrolyte shall be at the full level and of the specified specific gravity.

Equipment furnished with finished coats of paint shall be touched up by the Contractor if their surface is spoiled or marred while handling.

Foundation work and grouting-in of fixing bolts or channels for all transformers, switchgear, motors, and control panels will be carried out by the Contractor.

Precautions

The approval by the Engineer of the Contractor's proposals for rigging and hoisting of any item of plant into its final position shall not relieve the Contractor from his responsibility for avoiding damage to completed structures, parts or members thereof or other installed equipment. He shall at his own cost make good, repair or replace any damaged or injured items whether structural, mechanical, electrical, architectural, or of any other description, promptly and effectively to the satisfaction of the Engineer.

No plant or other loads shall be moved across the floors of structures without first covering the floors with timber of sufficient size so that applied loads will be transferred to floor beams and girders of steel or concrete. If it is required to reduce bending stresses or deflection, the beam and girders shall be provided with temporary supports. Any movement of Plant and other loads over the floor structures shall be subject to the prior approval of the Engineer.

14.25 Civil Inspection (Water Leakage Test)

14.25.1 Tanks and basins

Refer to Part 11 – Particular Civil and Structural Works Requirements of the Bid Document

14.25.2 Field Control Inspection

Contractor shall conduct periodic field control inspection to prevent any field accident. The Engineer shall joint field inspect or conduct unannounced inspections.

14.25.3 Inspection after Erection

After the erection of any item of Plant and its associated equipment has been completed, it shall be offered to the Engineer for inspection in its static state prior to commissioning the item.

Completion of erection and procedure prior to setting to work.

The mechanical completion of plant under erection shall be deemed to occur if all the units/systems of the Works are structurally and mechanically complete as noted below:

All rotary, static, structural equipment, piping, electrical/instrumentation and other equipment under the scope of the Contract have been erected, installed and grouted and are as per the specifications.

All systems have been washed/flushed/drained/boxed up where necessary.

All system testing including pressure, vacuum and nondestructive tests, no load tests and such other tests are completed with safety valves/relief valves set to operating conditions installed in position.

All panels, local control desks erected with power/control cable terminations with all continuity checks, insulation checks and other installation checks are carried out.

All electrical equipment after the completion of erection shall be tested as per the requirements of National Electrical Code SP:30-2023, Part 1, Section 17.

Prior to pre-commissioning checks, the Contractor shall erect the entire Plant and ensure readiness of civil works to the satisfaction of Employer, so that the Works are physically ready to undergo pre-commissioning checks. Pre-commissioning checks will include checks like no-load running of machinery, checks on instruments and electrical including calibration and loop checks, functional checks, inter-lock checks etc.

At the stage of mechanical completion of erection, the Contractor shall ensure that all the physical, aesthetic and workmanship aspects are totally complete and the Plant is fit and sound to undergo pre-commissioning checks.
The following documentation shall be completed before the Contractor notifies Mechanical Completion of Erection to the Employer

(a) All shop inspection records compiled and bound in 4 (four) copies.
(b) All erection and commissioning procedures duly approved.
(c) All instruction manuals in draft form - with each sheet bearing a stamp to indicate "DRAFT FOR REVIEW ONLY" submitted in 4 (four) copies.

Upon achieving mechanical completion, the Contractor shall notify the Employer of such completion of section/units/systems and readiness for inspection for acceptance of mechanical completion of erection. The Employer/ Engineer shall proceed with inspection of such sections/units/systems within 10 days of such notice.

Consequent to inspection, the Employer will inform the Contractor a list of deficiencies for rectification and the Contractor shall complete the rectification work within a jointly agreed period prior to start of pre- commissioning tests. The erection period allowed by the Contractor shall include all activities of mechanical completion as noted above.

14.26 Site Acceptance Test Document

Fifty-six (56) days prior to commencement of Tests on Completion the Contractor shall supply a Site Acceptance Test (SAT) Document for approval. This shall comprise four copies of the details of the inspection and test procedures to be carried out in testing the Works.

The SAT Plan shall provide comprehensive details of the tests to be carried out, the purpose of each test, the equipment to be used in carrying out the test and the methods to be adopted in carrying out the tests. The SAT shall provide space within the documentation for results of the tests to be added and for each test and for the SAT as a whole to be signed off by the Contractor and the Engineer.

The SAT shall categorise tests as follows:
a) Dry tests
Dry tests are those tests carried out without process fluid being present.

b) Wet tests which can be further sub-divided into
(1) Hydraulic tests
Hydraulic wet tests are those tests carried out with potable water in order to prove the hydraulic Capability of the Works.

(2) Process tests /System tests
Process wet tests are those tests carried out with raw Sewage as the feed stock to prove the process Capability of the Works.

The Contractor shall make his own arrangements for water supply, chemical, electric power, fuel, instrument and labour during hydraulic wet tests.

It shall be assumed that the co-operation of other Contractors in the carrying out of Tests on Completion will not be unreasonably withheld.

14.27 Tests on Completion

14.27.1 General

Prior to the commencement of Tests on Completion the Contractor shall submit for approval the following:

(1) Site Acceptance Test Documents
(2) As-Built Drawings
(3) Operation and Maintenance Manuals
(4) Site test results / data sheet and photo

Tests on Completion shall not be commenced until the aforementioned documents are approved.

The initial charges of oil, grease, electrolyte, generator fuel / oil, chemical, disposal of cake, etc. necessary for Tests on Completion shall be provided by the Contractor. Raw Sewage and electricity required for Tests on Completion will be provided by the Employer free of charge. If necessary, Contractor shall create design loading conditions for testing purposes by testing fewer than the total number of installed units of process tanks or equipment at a time. In such cases, multiple tests shall be conducted to ensure that all installed units are tested. In the event that raw sewage/influent wastewater is not available at the plant, the Contractor shall defer testing until such time as sewage becomes available for treatment as described elsewhere in these Bid Documents. The Contractor shall provide adequate notice (this notice period shall be determined by the normal lead time for locally purchased chemicals plus at least 28 days) of his chemical requirements prior to commencement of the Tests on Completion involving their use.

The cost of chemicals used for the Tests on Completion shall be met by the Contractor.

The inspection and tests procedure which will be carried out are provided under the general conditions of contract and shall also consist of the following:

a) Manual Commissioning Tests (Clause i)

Manual Commissioning Tests shall be such preliminary trials, tests and retests on individual items of Plant or complete systems as are required by the Engineer in order to demonstrate that the Plant as a whole is ready to undergo the Manual Operation Tests (Clause 3.11) and that these will take place with a minimum of interruption.

The Manual Commissioning Tests shall demonstrate not only the items of Plant under normal operation, but also their response to abnormal and emergency conditions.

The Engineer will notify to the Contractor which items of Plant will be tested and the extent to which they will be tested in order to fulfill the requirements of the Specification.

Leakage tests at 1.5 maximum working pressure shall be carried out on all erected pipe work prior to the Manual Commissioning Tests.

Pump curves shall be available for the Manual Commissioning Tests and all instruments essential for the tests shall have been calibrated.

b) Manual Operation Tests (Clause ii)

When the Manual Commissioning Tests have been completed so that the items of Plant have been demonstrated to the satisfaction of the Employer Representative, the Contractor shall commence the Manual Operation Tests.

These tests shall demonstrate the correct operation of the whole Plant whilst using the minimum quantity of automatic control and monitoring equipment. Such equipment shall be at least that required both for the maintenance of safety and for the normal mode of operation of the Plant.

The Plant will be required to demonstrate satisfactory operation at all design flow rates.

The tests shall be of seven consecutive days' duration; if the supply of water should fail or other matters interfere outside the Contractor's control, the tests may be of such number of broken days as the Engineer considers is the equivalent.

The exact date of commencement shall be subject to the approval of the Engineer and shall be dependent on the following conditions having been met

(1) All relevant items of Plant in approved working order
(2) All items of Plant correctly identified with labels

c) Automatic Commissioning Tests (Clause iii)

The Automatic Commissioning Tests shall be such preliminary trials, tests and retests on individual items of Plant or complete system as are required by the Engineer in order to demonstrate that the Plant as a whole is ready to undergo the Tests of Completion (Clause 3.13) and that these will take place with a minimum of interruption.

At least one week before the commencement of these tests, the Engineer will notify the Contractor which items of Plant will be tested and the extent to which they will be tested in order to fulfill the requirements of the specification.

The Tests on Completion (Clause 3.13) as provided under the general conditions of contract-clause 37 shall not be carried out until the completion of the above tests.

(1) All pipe work shall be hydrostatically tested at site to a pressure equal to 1.5 times the maximum working pressure likely to be encountered in the system.

(2) The Contractor shall carry out all tests on the Plant and shall supply four copies of all test results to the Engineer.

(3) All tests shall be to the approval of the Engineer who may require them to be repeated, prolonged or modified as may be necessary to ensure that any or all items of Plant conform to the Contract.

(4) The Engineer shall be permitted to inspect all Plant which is undergoing tests and may himself conduct tests.

Where it is necessary for the Engineer to make arrangements for the supply of water, chemicals, power, etc., for any testing, the Contractor shall not commence the tests until after these arrangements have been made on or after a date agreed by the Engineer and the Contractor shall make no claim for delay to such testing on this account except as provided for under Clauses 44 of the General Conditions of contract.

If any item of plant fails during or after testing to achieve its intended duty or otherwise proves defective, it shall be modified or altered as necessary and re-tested and re-inspected as required by the Engineer.

Vibration/noise level tests shall be carried out at site which will form basis for acceptance of the equipment. If the Contractor is not in a position to meet the requirements given below as per ISO 10816 – 1995, the equipment may either be rejected or the Contractor shall carry out all necessary modifications to keep vibrations within the acceptable limits specified.

Equipment	Noise Level (dB at 1.0 m from equipment)	Velocity of vibration (mm/sec)
All rotating equipment not having Reciprocating parts with motor kW less than or equal to 15 kW	80	1.12
All rotating equipment not having reciprocating parts with motor kW more than 15 kW and less than or equal to 75 kW	80	1.8
All rotating equipment not having reciprocating parts with motor kW greater than 75 kW	80	2.8
All equipment having reciprocating parts viz. compressors, dosing pumps sampling pumps	80	-

The Contractor shall have a minimum of three commissioning engineers, one for process and plant and the other for mechanical/electrical/instrumentation works on site during all tests in order to both demonstrate the Plant and to correct any faults which may occur.

14.28 Dry Test Requirements

As a minimum requirement the following dry tests shall be carried out as a general requirement:

(1) A general inspection to check for correct assembly and quality of workmanship
(2) A check on the presence of lubricant, cooling medium, electrolyte, etc.
(3) A check on adequacy and security of Plant fixing arrangements.
(4) A general check to ensure that all covers, access ladders, water proofing, guard railings etc. are in place.
(5) A check on damp-proofing, rust-proofing and vermin-proofing and particularly the sealing of Apertures between building structures, chambers etc. and the outside.

a) Civil and Building Works

As a minimum requirement the following dry tests shall be carried out on the civil engineering and building works:

- Check for the presence of foreign bodies in pipe work and structures.

b) Mechanical Works

As a minimum requirement the following dry tests shall be carried out on the mechanical systems:

- Carry out preliminary running checks as far is permitted by circumstances in order to ensure smooth operation of Plant.

c) Electrical Works

All electrical equipment & installations shall be tested as per requirements provided in National electrical Code, SP-30-2023, Part 1, and Section 17:

14.29 Process Plant Item / Equipment

All process plant items / equipment shall be tested to ensure they meet the Employer's Requirements for quality of workmanship, construction and performance.

14.30 Hydraulic Wet Test Requirements

Hydraulic wet tests shall be carried out on completion of dry tests.

Clear Water shall be used for hydraulic wet tests. The purpose of the tests is to prove the hydraulic performance of the Works. In order to demonstrate this, the Contractor shall ensure that each part of the Works is hydraulically loaded to its rated throughput for a period of at least four hours.

In order to ensure a sufficient supply of water to carry out these tests the Contractor shall provide all required facilities, including but not limited to any temporary facilities that may be required for storage and recycle of Clear Water or facilities for the disposal of the water off Site in an approved manner.

The following tests inter alia shall be carried out:

1. Pressure testing of all piped systems laid direct in ground in accordance with the relevant standards.
2. Fill all structures and check for leaks.
3. Filling of all storage vessels to check for leaks and distortion.
4. Running of all pumped systems in order to check for.

i) Correct functionality.
ii) Absence of leaks.
iii) Correct running temperatures.
iv) Smoothness of running and the absence of undue vibration or stress.
v) Check drive running currents.

5. Carry out calibration of instruments where appropriate.
6. Carry out valve operation, diversions etc. to fully hydraulically load each process element (or where there is a requirement to withstand an overload), overload each process element.
7. Demonstrate correct functionality of electrical, control and instrumentation systems.

The Contractor shall simulate the conditions that will prevail when operating as a process in order to demonstrate the correct functionality of process control loops etc.

During these tests a check on the performance of Plant shall be made to compare its site performance with the factory test data and to identify any constraints on performance due to site conditions.

14.31 Safety Audit

After satisfactory completion of hydraulic wet tests and prior to introduction of process fluid to the plant a safety audit shall be carried out to ensure compliance with the necessary requirement for safety and for operation of Plant. The safety audit shall be documented. The safety audit document shall be approved by the Engineer prior to commencement of Plant commissioning.

14.32 Process Wet Tests (with Raw Sewage)

On approval by the Engineer the Contractor shall carry out process wet tests.

Raw Sewage shall be used as the main feed stock for process wet tests. These tests shall be carried out to demonstrate the process performance of the Works. In order to demonstrate this, the Contractor shall ensure that each part of the Works is loaded to its rated throughput (including a period of overload if required in order to demonstrate compliance with the Employer's Requirements) for a continuous stable operating period of not less than 48 hours. If necessary, Contractor shall create design loading conditions for testing purposes by testing fewer than the total number of installed units of process tanks or equipment at a time. In such cases, multiple tests shall be conducted to ensure that all installed units are tested.

The Contractor shall provide all required facilities for the disposal off Site in an approved manner.

The following tests inter alia shall be carried out:

(1) Check for leaks on vessels, structures, pumps and pipework.
(2) Running of all pumped systems in order to check for.
   - Correct functionality.
   - Absence of leaks.
   - Correct running temperatures.
   - Smoothness of running and the absence of undue vibration or stress.
   - Check drive running currents where the solution pumped is different from that pumped during hydraulic wet tests.
(3) Carry out calibration of instruments.
(4) Carry out valve operation, diversions etc. to fully hydraulically load each process element (or where there is a requirement to withstand an over load), overload each process element.
(5) Demonstrate correct functionality of electrical, control and instrumentation systems not checked during dry or hydraulic wet tests or which may have changed as a result of the different operating conditions now prevailing.

On completion of the tests on the various parts of the works the Contractor shall run the plant as a whole in order to demonstrate the full functionality and performance of the Works at various through put rates for a continuous period of not less than 30 days.

During the various process tests the Contractor shall perform sampling and analysis of all the process streams (locations) and parameters listed in the "Sampling/Analysis Locations and Frequencies" table provided in the "Tests after Completion" Section below. The frequencies listed in this table shall be followed for the Tests after Completion. However, for the Process Wet Tests performed as part of the Tests on Completion, the sampling frequency for all locations and all parameters shall not be less than once every hour. The Contractor shall demonstrate to the Engineer that the Works is functioning in accordance with the Employer's Requirements. Each sample shall comprise two 1 litre (minimum) quantities and shall be labelled to identify the contents, where taken and time and date. The flow recorded at the time of sampling shall also be indicated in the log book or record. One sample shall be used by the Contractor for his analysis; the other shall be handed over to the Engineer.

The Engineer reserves the right to take additional samples and to carry out his own tests or to check the samples taken by the Contractor.

The Engineer shall be given reasonable access to the premises where analysis is taking place in order to check on working practices and the procedures being adopted.

14.33 Effluent Quality Criteria for Passing the Tests on Completion

The Works shall be considered to have achieved the required effluent quality standards for passing Tests on Completion if all samples taken during a 30 day continuous operational period comply with the criteria set down for passing the Tests after Completion. This includes criteria relating to the reliability of the plant.

The Effluent quality Tests on Completion shall not be commenced until all tests associated with the civil/building, electrical and mechanical works and individual process tests have been completed to the satisfaction of the Engineer.

14.34 Co-operation with other Contractors in the Execution of their Tests

The Contractor shall, where required, assist other Contractors in carrying out their tests on completion and or tests after completion.

Where this assistance does not constitute part of the Contractors own work associated with Tests on Completion or Tests after Completion the Contractor shall be reimbursed at the rates approved by the Engineer.

14.35 Tests after Completion

General

On successful completion of "Test on Completion" the Contractor shall carry out over a period of time not exceeding six months two separate 30 days operational tests. These tests shall be used to prove the operation of the Works at varying flows and with varying raw Sewage quality. During these tests Effluent produced by the Works will be entering the disposal system. These tests after completion shall be undertaken in accordance with the Volume 1, General Conditions of Contract.

The timing of the tests shall be determined by the Employer who shall give notice to the Contractor in accordance with the Volume 1, General Conditions of Contract. The total time for carrying out the tests shall not be less than six calendar months. One of the tests for each part shall be carried out in a period of high raw Sewage BOD and suspended solids.

On commencement of each 30-Days test the Employer shall allocate a continuous period of not greater than 60 days to complete the test. Any failure to perform during the 60 days period shall restart the '30 day clock'. If the part of the Works fails to pass the test in the 60 days period the test shall be deemed as a failure and the Contractor shall carry out any necessary remedial work to the satisfaction of the Engineer before the Contractor restarts the test.

During the tests the Contractor shall take samples to demonstrate that the part of the Works is performing in accordance with the Employer's Requirements. The procedure for taking the samples shall follow the pattern adopted for Test on Completion. Samples shall be taken at locations and intervals as detailed in tender document. The results of the Tests after Completion shall be compared and evaluated by the Employer and Contractor.

The Contractor will not be held responsible for interruptions to the sewage treatment process as a result of Grid power failures (unless as a result of a Plant failure) interruptions in the raw Sewage supply etc. which are out of his control. However, the Contractor shall be required to demonstrate that the Works

can cope with these inevitable interruptions in an orderly fashion and recover to a normal operational state with the minimum of manual intervention.

All consumables except power needed for operation of the Works shall be provided by the Contractor.

The Contractor shall provide all facilities and equipment not supplied under the contract and which are deemed necessary for the Contractor to carry out and monitor the Tests after Completion.

Criteria for Passing the Test after Completion

(1) Treated Effluent and Dewatered Sludge Quality Criteria

The Works shall be deemed to have met the Treated Effluent and Dewatered Sludge Quality Criteria if:

(i) at least 95 percent of the plant effluent samples described above meet the requirements specified under the "Effluent Quality Requirements" sub-section of Volume 2, Section 1, Part 5, and

(ii) at least 95 percent of the dewatered sludge samples described above meet the requirements specified under the "Dewatered Sludge Quality Requirements" sub-section of Volume 2, Section 4, Part 5.

(2) Operational Cost Criteria

The plants shall have fulfilled the operating cost criteria if the operating costs determined during the Tests After Completion are in agreement with or less than those detailed in the Contractor's Functional Guarantee, or an amount of liquidated damages are agreed by the Contractor and the Engineer to compensate for any short fall in performance up to an agreed maximum amount if stated.

(3) Plant Reliability Criteria

A part of the Works shall be deemed to have failed its test if:

(1) A single item of Plant / equipment fails more than twice during the test.

(2) More than four individual Plant items / equipment fail.

An item of Plant / equipment shall be deemed to have failed if manual intervention is required in order to restore the Plant / equipment to its fully operational state: i.e. the failure of a duty drive will be considered as one failure, if the standby drive fails to start that will be considered as a second failure.

14.36 Performance Certificate

The conditions for issuance of a Performance Certificate as detailed in the Volume 1, Conditions of Contract shall inter alia comprise:

a) The completion of the six months operation of the Works (Tests after Completion) to the satisfaction of the Engineer.

b) The O & M Manuals have been updated following one year's operational experience and approved by the Engineer.

c) All defects identified prior to Taking Over and defects identified during one year operation of the Works have been rectified.

d) All Tests "After Completion" have been completed to the satisfaction of the Engineer.

e) All training detailed in the Employer's Requirements has been completed.

14.37 Sampling/Analysis Locations and Frequencies

Refer sub-section of Volume 2, Section 7, and Part 5 for Sampling/Analysis Locations and Frequencies.

14.38 Prices for Inspection, Testing and Commissioning

The Contractor, at the time of bidding, shall be responsible to ensure the completeness and adequacy of his Bid Price to full-fill the entire responsibilities as described above. His bid price, as quoted on in the Schedule of Prices, shall include all costs including but not limited to expenditure for personal, Prices for to-and-fro travelling, Prices for onsite Inspection, Testing and Commissioning site.

End of Part-14

PART 15

TRAINING AND ADVISORY REQUIREMENTS

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PART 15

TRAINING AND ADVISORY REQUIREMENTS

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PART 15

TRAINING AND ADVISORY REQUIREMENTS

15.1 Training Requirements

15.1.1 General

The Contractor shall provide comprehensive training for the different categories of the Employer's operation and maintenance staff. Training shall fall into two main types, which are 'off the job' and 'on the job'. Off-the-job training shall take place in the classroom; on-the-job training shall be carried out in the running plant.

15.1.2 Off the Job Training

The Contractor shall prepare formal training documentation for distribution to the trainees. Visual aids shall be used where possible to illustrate the points being made and to make the training programme as interesting and enjoyable as possible for the participants.

Table 15. 1: Off the Job Training Requirements:

Training Category	Training Requirements
1) Off the Job Training Programme for all Trainees	a) On the simple chemistry, biology and process principles involved in the operation of the Works. b) Health and safety. c) Plant safety procedures. d) On the use of the local and central HMIs.
2) Off the Job Process Training Programme for Plant Operators	a) On the operation of individual items of plant and sections of the works, including automatic and manual operation in the event of automatic control failure. b) On the day-to-day operation of the Works, procedures, and troubleshooting. c) On a comprehensive list of "what if" scenarios dealing with the actions to be taken in the event of potential process problems, alarms, plant failures, overflows, power failures etc. d) On the first line, mechanical maintenance. e) On general safe methods of work. f) On safety procedures to be followed in operating, maintaining and cleaning the plant. g) On special precautions to be followed in the event of a chlorine leak. h) Developing standard operating procedures.
3) Off the Job Training Programme for Electrical Maintenance Staff	a) On the configuration, construction and operation of the electrical Plant. b) On the electrical maintenance requirements of the works. c) On the switching and safety procedures to be followed.

Training Category	Training Requirements
	d) On safe methods of working. e) On fault finding and repair procedures.
4) Off the Job Training Programme for Control and Instrumentation Maintenance Staff	a) On the configuration, construction and operation of the Plant. b) On the control and instrumentation maintenance requirements of the works. c) On fault finding and repair procedures. d) On safe methods of working. e) Special training on the use of the PC and associated programming software for fault finding on PLC based control systems. f) Special training on the use and performance of the central HMI SCADA hardware and software and other specialist hardware and software systems used in the plant.
5) Off the Job Training Programme for Mechanical Maintenance Staff	a) On the routine mechanical maintenance requirements of the Works. b) On lubrication requirements of the works. c) On fault finding, repair and overhaul procedures. d) On safe methods of working.
6) Off the Job Training Programme for Sewage Treatment Management Staff including safety officer	a) Wastewater treatment process management techniques. b) Wastewater treatment plant cost management. c) Wastewater treatment plant laboratory management. d) Safe methods of work general. e) On safety procedures to be followed in operating, maintaining and cleaning the plant. f) Communication strategy and cascading information
Note: *Training shall be mandatory for all AMC vendor packages.*	

15.1.3 On the Job Training

The Contractor shall utilise the Operations and Maintenance Manuals as the primary training aid in carrying out the on the job training. Shortcomings, omissions and errors identified in the O & M Manuals during the training shall be rectified prior to final acceptance of the O & M Manuals.

Table 15. 2: On the Job Training Requirements

Training Category	Training Requirements
a) On the Job Training Programme for all Trainees	a) Plant familiarisation tour. b) On the use of the local and central HMIs. c) Health and safety. d) Identify areas where special safety precautions are necessary.
b) On the Job Process Training Programme for Plant Operators	a) Under operational conditions on the operation of individual items of plant and sections of the works including automatic operation and manual operation in the event of automatic control failure.

Training Category	Training Requirements
	b) Illustrate by example the day-to-day operation of the works and procedures. c) Illustrate by example the actions to be taken in the event of potential process problems, alarms, plant failures, overflows, power failures etc. (as identified in the 'what if' scenario off the job training). d) Illustrate by example the first line mechanical maintenance. e) Illustrate by example safety procedures to be followed in operation, maintenance and cleaning of the Works, as well as emptying tanks and other parts of the works and bringing units into operation following emptying/decommissioning.
c) On the Job Training Programme for Electrical Maintenance Staff	a) Carry out detailed tour of the electrical plant. b) Illustrate by example the operation of the electrical plant. c) Illustrate by example the electrical isolation and maintenance procedures. d) Illustrate by example fault finding and repair procedures. e) Illustrate by example switching and safety procedures to be followed. f) Illustrate by example safe systems of work.
d) On the Job Training Programme for Control and Instrumentation Maintenance Staff	a) Illustrate by example the operation of the Works. b) Illustrate by example the control and instrumentation maintenance requirements of the Works. c) Illustrate by example fault finding and repair procedures. d) Illustrate by example fault finding on PLC based control systems, the central HMI SCADA hardware and software and other specialist hardware and software systems used on the plant. e) Illustrate by example safe systems of work.
e) On the Job Training Programme for Mechanical Maintenance Staff	a) Illustrate by example the routine mechanical maintenance requirements of the Works. b) Illustrate by example lubrication procedures. c) Illustrate by example fault finding, repair and overhaul procedures. f) Illustrate by example safe systems of work.

15.1.4 Training Programme

Mandatory training occasions for various training category are listed in Table 15. 3:

Table 15. 3: Training Programme

Type of Training	Training Programme
Off the Job Training for various training category as listed in Table 15. 1.	1) Training programme shall be conducted prior to issue of the Commissioning Certificate for Works or any Section of the Works. 2) Training programme shall be conducted prior to start of the first joint inspection of the plant at the time of Handover. (Refer Part 17)

Type of Training	Training Programme
On the Job Training for various training category as listed in Table 15. 2:	1) Training programme shall be conducted after issue of the Commissioning Certificate for Works or any Section of the Works. 2) Training programme shall be conducted after the approval of second joint inspection report of the plant at the time of Handover. (Refer Part 17)
Annual Training Programme	1) Annual training programme shall be conducted for all O&M staff and Employer nominated Engineer covering some of basic information: - Training on Health and Safety. - Structured communication plan. - Revisiting basic process information. - Standard O&M calculations. - Simulation Model for improving plant performance. - Optimization of power and chemical consumption. - Lessons learnt from previous year of O&M. - Training on All aspects of O&M Works. - Training on PLC and SCADA. - Training on plantation and landscaping and keeping pleasant and neat environment of build out campus. - Making innovation in routine work. - Way Forward.

The Contractor shall provide a training plan for each category of staff. The training plan shall detail the content and duration of each course. The training plan shall be submitted for the approval of the Engineer at least 90 days prior to the commencement of the Tests on Completion of Design-Build. The duration of training offered for each category of staff shall not be less than that detailed in the following table.

Table 15. 4: Minimum Training Duration Requirements at Each Training Programme

Category of Staff	Minimum days duration for each course	
	Off the Job Training	On the Job Training
All staff	1	1
Plant Operator	3	5 (see note)
Electrical technician/electrician	3	3
Control/instrument technician	5	3
Mechanical technician/fitter	3	3
Plant Manager	3	(see note)

Notes:

1) It is assumed that for the Plant Manager on the job training will be continuous throughout the initial 12 months of the Operation Service Period and intermittently/as required thereafter.

2) On the job training of the Plant Engineer/Operators who are assigned by the Employer to work full time during the Operation Services Period (including replacement staff) shall be provided

Category of Staff	Minimum days duration for each course	
	Off the Job Training	**On the Job Training**
continuously throughout the initial 12 months of the Operation Service Period and intermittently as required by the Employer thereafter. (Refer Paragraph 15.4) *3) The training day shall be assumed to be not less than 6 hours split into two sessions.* *4) The "Off the job" training rooms shall be provided by the Employer in the existing buildings or another suitable location. However, Contractor shall provide facilities for training which shall include inter alia tables and chairs, projectors, white/black boards, training aids etc.,* 5) *Where trainees of a given category can all be released from their Works operational duties simultaneously, they may be trained together. Where this is not possible the Contractor shall repeat the complete course for those who could not attend.*		

15.1.5 Training Requirements for ICA Works

A. Before Conduction of Site Acceptance Test (SAT)

The Instrument Control Automation (ICA) system supplier shall conduct training courses for personnel selected by BWSSB. Training shall be conducted by personnel employed by the Contractor/ system supplier familiar with the system supplied and who have experience and training in developing and implementing ICA courses.

Training shall be conducted for a minimum period of Five (5) days for at least five BWSSB personnel on site, by the system suppliers (Field instrumentation, Analytical instrumentation, Online Real Time Multi Parameters Continuous Monitoring System for Influent and Treated Sewage Parameters, CCTV systems, Process equipment suppliers (vendor supplied systems), Plant operations, Control & Automation systems, Laboratory systems inclusive of LIMS, etc

The Contractor/ system supplier shall submit information on the training programme for approval, 45 days prior to training program. This submittal shall include a course outline; time required, course schedule, sample workbook and the instructor qualification information for each level.

The Contractor/ system supplier shall make a workbook on each course available to every person taking the courses listed herein. The workbook shall be of sufficient detail so that, at a later date, a trainee could review in detail the major topics of the course.

The training times shall be scheduled by the BWSSB in advance with the Contractor/ system supplier so as not to disrupt the BWSSB's/contractor ability to operate the plant.

B. After Conduction of Site Acceptance Test (SAT)

Training shall be provided for ten (10) of the BWSSB personnel at the WwTPs facility on operations and maintenance of all system components. The training program shall be divided into two segments and shall consist of at least 5 (five) working days, each of 8 (eight) hours duration. This shall include (Field instrumentation, Analytical instrumentation, CCTV systems, Process equipment suppliers (vendor supplied systems), Plant operations, Control & Automation systems, Laboratory systems inclusive of LIMS, etc

The maintenance training program shall be developed for personnel who have electronics maintenance and repair experience and a general knowledge of computer systems, but shall not assume any familiarity with the specific hardware furnished.

As a minimum, the following subjects shall be covered:

- System Architecture and Layout
- Hardware Components
- Module Switch Settings (Configuration Switches)
- I/O Modules
- Power Supplies
- Data Highway:
- Programmer connection
- IOP programming and diagnostic techniques
- Battery replacement and recharging
- PC and workstation familiarization and maintenance:
- Troubleshooting
- Disassembly
- Cleaning
- Component Replacement
- Re-assembly
- The operation training programme shall include the following topics:
- Power-up, bootstrapping and shutdown of all hardware devices
- Interpretation of all standard displays
- Appropriate actions for software and hardware error occurrences
- Use of operator interface displays and keyboards
- Use of printer including replenishment of supplies
- Manual data entries
- Creation and editing of graphic operator display screens.
- Loading of any required software into the system
- Data base creation and editing.

15.1.6 Training Personnel

The Contractor shall provide suitably qualified trainers to carry out the ‘off the job’ and ‘on the job’ training. The trainers are to be experienced in treatment plant management, process control, operation and maintenance and troubleshooting in their relevant discipline and in the training of skilled and unskilled staff.

The Contractor shall submit the curriculum vitae of the nominees to the Engineer for approval at least 90 days prior to the commencement of the Tests on Completion of Design-Build. The training experts/trainers shall be fluent in both English and Kannada or the Contractor shall provide the services of an interpreter during the training periods.

15.2 Advisory Requirements

15.2.1 General

The Contractor shall provide personnel to advise in the operation of the Works for a period of 1 year (expect for the advisor to the treatment works manager) after issue of the Commissioning Certificate for Works or any Section of the Works. The personnel provided shall have proven experience in their intended roles. Those persons provided shall comprise:

Advisor to the treatment works manager	:	Duration 24 months.
Advisor mechanical maintenance	:	Duration 6 months and thereafter intermittently over a period of 12months.
Advisor electrical/control maintenance	:	Duration 6 months and thereafter intermittently over a period of 12months.
Advisor process	:	Duration 6 months and thereafter intermittently over a period of 12months.

The electrical/control, mechanical and process specialist/advisor visits shall be split; the first visit to establish the procedures and implement, the second visit to monitor and refine the procedures.

The Contractor's personnel will be assisted by staff trained by the Contractor and provided in sufficient numbers to the Employer.

The role of the Contractor's advisory personnel shall be to:

- To advise on day-to-day management of the sewage treatment plants and intermediate pumping stations.
- To advise on the development procedures for the ordering and reordering of consumables.
- To propose and develop systems to monitor the consumption of consumables and power and to advise actions to reduce their usage to a minimum.
- To establish analytical procedures within the laboratory and carry out periodic checks to ensure that they are adhered to.
- To establish routines for the analysis of raw sewage, treated effluent quality and sludge quality and other parameters and to establish procedures for corrective action in the event of effluent quality falling below that required.
- To establish systems for the recording of the above parameters appropriate to a plant of this type
- Ensure procedures for operation and planned maintenance of the Works as detailed in the O & M Manuals are carried out and advise on improvements to the Manuals based on operational experience (refer also to final item).
- Advise on the optimisation of process settings, dosage rates, operating regimes etc, taking into account the increase in flows and pollution loads over time and the performance of the secondary treatment.
- Provide continuing informal on the job training to the Employers staff (this is in addition to formal training requirements detailed in bid document).
- Update the O & M Manuals in line with experience gained during the year's operation.

15.2.2 Advisory Personnel

The Contractor shall provide suitable personnel to provide advisory services. The advisors shall be experienced in treatment plant and pumping station operation and maintenance management.

The Contractor shall submit the curriculum vitae of the advisory nominees to the Engineer 90 days prior for the approval. Prior to mobilisation, the advisors shall be fluent in both Kannada and English or the Contractor shall provide the services of an interpreter/s during the advisory period as necessary.

15.2.3 Capacity Building

This Operation & Maintenance manual shall be provided by the Contractor to establish guidelines for plant operator to understand the new Sewage Treatment Plants and Intermediate Pumping Stations to operate these efficiently and successfully.

The guidelines will be provided to the training personnel on how to operate the Plant so that they shall be able to manage to treat sewage to the quality required; with less consumption of energy; with less cost of maintenance expenses; providing a long life of equipment; protection against accident, safe working methods and protecting systems from damages under all flow and pollution load conditions.

The system operation and unit operation of individual components may need to be adjusted and modified depending on the raw sewage characteristics and flows and the required data shall be collected during the training program as well as during the operation and maintenance period.

The Contractor shall train the Employer personnel about Plant operation knowledge, abilities and skill as follows:

Table 15. 5: Training Requirement for Capacity Building

Area of Capacity Building	Training Requirements
Knowledge	- System flow and unit operations, including maintenance, pumps, blowers, sludge dewatering, and other plant equipment and machinery. - Basic Sewage Treatment Process. - Basic sludge characteristics and principles of sludge handling. - Basic maintenance period and work sheet. - Basic laboratory techniques to make standardized tests. - Avoiding any chance of accident, and - Safety and Health.
Abilities	- Make adjustments to the wastewater treatment process based on the characteristics and flows of raw sewage, diurnal fluctuations in flow, and their control. - Equipment/feed pumps calibration techniques. - Make adjustments to control the chemical dosing systems, including the need to use alum to supplement biological phosphorus removal. - Use of/bypassing disc filters considering the quality of effluent from secondary treatment. - Adjust the chlorination process, and read and follow written and oral instructions. - Perform standardized laboratory tests. - Make repairs and/or adjustments to equipment and keep records and prepare reports, including graphical representation of data.

Area of Capacity Building	Training Requirements
	- Make repairs and/or adjustments to each equipment, keep records, and prepare reports. - Handling safety valves and associated pipelines. - Read and interpret gauges and recording devices used in the sewage treatment plant and intermediate pumping stations. - Usage of safety Equipment in case of Emergency.

15.2.4 Tasks of Operation and Maintenance Works

Tasks of maintenance and operation works shall include, but not necessarily be limited to the following:

- Operate sewage treatment plant under normal conditions such as equipment, machinery and pipe line, including valves, gates, stop-logs, pumps, screens, grit removal, aeration, blowers, pumps, clarifiers, disc filters, chlorination, dewatering equipment, chemical and polyelectrolyte preparation and dosing systems, reading flow meters; regulate sludge wasting, disposing of sludge.
- Select the treatment facility or equipment to meet actual performance, for example, the use of disc filters.
- Take samples and conduct standardized laboratory tests as required.
- Set the system/equipment to adjust the timer or operation period where necessary.
- Makes minor repairs and adjustments to machinery, equipment, pipes and other materials pertinent to the operation of the plant.
- Work on troubleshooting.
- Maintain maintenance and operational records.
- Cleaning of machinery, equipment and civil tanks, buildings, loading and unloading of materials and storage of chemicals properly.
- Carry out general maintenance of the plant, including, but not limited to, painting, general custodial work, equipment maintenance, checking the condition of the boundary wall and CCTV, and identifying potential issues such as leakages, damage from trees and tree roots, etc.
- Assist in repairing flow meters and pipelines, including valves, during both inactive and operational periods.
- Assist in inspecting all necessary equipment, sampling equipment, and pipelines.
- Maintain hygienic standards in acceptable condition.
- Maintain plantation & horticultural activities to give a pleasant environment on the built-out campus.

15.2.5 Operation and Maintenance Manual

The operation and maintenance manual shall include but not necessarily be limited to the following:

Table 15. 6: Information to be covered in the Operation and Maintenance Manual

Information	Details to be included
1) Background of project.	- Complete project background shall be included in manual.
2) Plan and design condition.	- As per approved designs.
3) System operation indices and unit operation indices.	- As per approved designs.

Information	Details to be included
4) Raw Sewage Quality & Quantity (Inlet / outlet).	- Site Actual. - Standard Requirement.
5) Outline of system operation (Civil, Mechanical & Electrical).	- Summary. - Flow diagrams, plan view, hydraulic profile, Piping isometrics. - Operation flow diagram. - Table of facilities. - (Tag number, Type, Number, Nominal bore, capacity, motor rating, and weight).
6) Outline of component and its aim (Civil & Mechanical).	- Normal operation. - Emergency operation. - Selection of facility. - Selection of Auto/Manual mode. - Notice of danger/peril/hazard.
7) Verification items of system operation mode (Civil & Mechanical).	- Before the system is operational. - Start of system operation. - During regular operation. - Set the value of the level sensors and the safety pressure on the safety devices. - Position of plant/equipment on the selected mode. - Remove potential dangers, perils, or hazards.
8) Detail of facility/equipment component (Civil & Mechanical).	- Summary. - Specification. - Outside dimension. - Weight, quality of material. - Outside drawing. - Graph, charts, performance curve, table. - Photo after installation. - Notice of danger/peril/hazard.
9) Verification items of component operation (Civil & Mechanical).	- Preparation before the operation. - Starting operation flow. - Normal operation. - Set value of level sensors and safety valves. - Emergency maintenance. - Notice of danger, peril, hazard.
10) Outline of component and its aim (Electrical).	- Verify incoming power Hz, kWh. - Ordinary line or Emergency line operation. - Detail and full operation procedure. - Select standby generator. - Emergency operation.

Information	Details to be included
	- Selection of facility. - Notice of danger/peril/hazard.
11) Verification items of system operation mode (Electrical).	- Before start of system operation. - Start of system operation. - Set value of level sensors and protection. - Select Auto/Manual mode on central control panel. - Remove potential danger/peril/hazard.
12) Detail of facility component (Electrical).	- Summary. - Specification. - Single line diagram. - Panel dimension. - Weight, quality of material. - Outside drawing. - Graph, charts, performance curve, table. - Photo after installation. - Notice of danger/peril/hazard.
13) Facility verification items (Electrical).	- Preparation before the operation. - Select Normal operation or Emergency operation. - Select equipment operation mode/switch by Auto /manual. - Before start of system operation. - Start of system operation. - Set value of level sensors and protection. - Remove potential danger/peril/hazard. - Notice of danger/peril/hazard.
14) Standard	- Water quality at inlet and outlet. - Emission control. - Noise and vibration.
15) Fire/explosion protection.	- Fire Safety - Mock Drill
16) Dewatered cake sludge handling/disposal.	- Site Actual. - Standard Requirement.
17) Frequency of sampling, analysis and evaluation.	- Inflow and outflow Quality /flow rate. - Regulated pollutants. - Operation index. - Amount of sludge and its density. - Sewage / sludge temperature.
18) Maintenance schedule (Mechanical & Electrical).	- Routine work. - Regular work. - Manufacturer recommendation.

Information	Details to be included
19) Maintenance schedule (Civil).	- Routine work. - Regular work. - Manufacturer recommendation.
20) Calculation sheets	- Calculation of dosing amount (Alum/Chlorine/Poly/etc). - Calculation of sludge amount and characteristics.
21) Troubleshooting guide (Phenomenon/action/comments).	- Effluent quality, bulking and foaming. - Process and system control. - Mechanical equipment. - Electrical equipment. - Case study or/and previous experiences (Normal troubleshooting).
22) Operation / test data.	- Operation index. - Mechanical site inspection data. - Electrical site inspection data. - Water quality and quantity (inlet/outlet). - Regulated pollutants. - Amount of sludge and its density. - Amount of cake and its density. - Noise and vibration. - Water / sludge temperature. - Power /chemical consumption. - Operation cost during training period. - Performance test of pressure control valves, pressure reducing valves. - Consumables, spare parts and its list. - Photos of inspection (evidence).
23) List.	- Equipment control. - Operation record formats. - Maintenance record formats. - Material control. - Inventory. - Spare parts. - Safety and Health.

15.3 Prices for Training and Advisory

The Contractor, at the time of bidding, shall be responsible to ensure the completeness and adequacy of his Bid Price to fulfil the entire "Training and Advisory" responsibilities as described above. Contractors bid price, quoted in the Schedule of Prices, shall include all costs related to the complete training and advisory program as described. This include but not limited to reasonable per diem expenses for meals, lodging, transport, and other similar expenses for all BWSSB personnel attending the training.

15.4 Employer's Plant Operator

During (Ten) 10 years Operation and Maintenance period of WwTPs, Employer may/might appoint one Plant Operator (General shifts) for WwTP in addition to contractor's operational staff. This Employer's Operator should be trained by the Contractor at his own cost; further Contractor should make Employer's Operator involved in all day-to-day Operation and Maintenance activities of WwTPs, such that Employer's Operator should be competent to take over Operation and Maintenance of WwTP during handing over period.

Employer's Operator shall report to concerned Engineer from Employer and wages towards Employer's Operator shall be directly paid to Employer's Operator from Employer.

Contractor shall make note that Employer's Operator is not authorised to certify any of the Contractor's monthly O&M bills, however Employer's Operator responsibilities shall be similar to the responsibilities of Plant In charge and/or Plant Manager.

End of Part 15

PART 16

OPERATION AND MAINTENANCE

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PART 16

OPERATION AND MAINTENANCE

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PART 16

OPERATION AND MAINTENANCE

16.1 Operation and Maintenance Requirements

This section applies to the specifications of materials used for operation and maintenance, the workmanship, period for routine maintenance, specifications for the acceptable quality of plant effluent, maintenance of records, and responsibilities during the Operation Service Period. The Contractor shall provide access to the Site for the Employer/Employer's Representative for the purpose of monitoring the Contractor's Operation Service activities during the Operation Service Period. The Contractor shall train the Employer personnel who will operate the Works/plants (Refer to Part 15). Entering into AMC contracts with system / equipment suppliers including but not limited to Centrifuges, Air Blowers, Hoists and cranes, Valves and actuators, Sluice Gates and actuators, all pumps and mixers, Chlorinators, DG sets and all proprietary equipment and others as necessary.

The Contractor shall operate and maintain the Wastewater Treatment Plant (WwTP) and Terminal Sewage Pumping Station (TSPS) under the Contract complete including the road works, landscaping, civil/structural, mechanical components, instrumentation system, Electrical System of WwTP and TSPS & ISPS, SCADA systems, all utility and ancillary buildings, TSPS and WwTP premises areas for the period of Ten (10) years from the date of the Commissioning Certificate, in accordance with the Conditions of Contract.

The Contractor shall manage plant operations so as to restrict power consumption and chemical usage within the specified functional guarantees.

The Contractor shall ensure satisfactory operation and maintenance of the whole works so that the plant operation provides reliable, consistent performance and is economical at all times.

The Contractor shall make his own arrangements at his own cost for plant operation personnel, chemicals usage, lubricants, diesel, spares, tools and tackles, routine maintenance, sampling and analysis, screenings and grit collection, transportation and disposal, dewatered sludge disposal/sale, co-ordination with Employer, Karnataka State Pollution Control Board (KSPCB), Karnataka Power Transmission Corporation Ltd. (KPTCL) authorities and any other activity required for the operation and maintenance of the works / plants in full compliance with all applicable rules, regulations, laws, codes, effluent quality requirements and any other limitations.

Normally shut down time shall be considered as Average two (2) Hrs per day. Contractor shall pay for diesel charges for running the WwTPs/TSPSs and ISPSs for this period. Employer will pay for any additional consumption of diesel when power shutdown period exceeds Sixty (60) hours per calendar month to a TSPS/ WwTPs.

The cost of electrical energy consumed for the operation of the Plant will be borne by Employer up to the amount corresponding to the guaranteed specific energy consumption specified by the Contractor in the **Technical Schedule V** or as agreed between BWSSB and the Contractor. However, Contractor shall bear the additional electrical energy consumption charges above the amount calculated as per **Technical Schedule X**.

During the Operation Service Period, the Contractor shall collect, transport, and dispose of the screenings, grit, and dewatered sludge cake in full compliance with all applicable laws, rules, and regulations.

The Contractor shall submit a weekly and monthly report to the Employer detailing the Operation and Maintenance indicating the labour hours expended, Electrical Power Consumed, Chemicals and other Consumables consumed and also any problems including troubleshooting faced and rectified. The report shall also include full details including photos and complete results of all sampling and analysis conducted. The sampling locations, parameters analysed, and sampling/analysis frequencies shall be as listed in the paragraph "**Locations and Frequencies for Sampling & Online Analyzers / Measurements"** of Part 5, Section 7, Volume 2 of the Bidding documents as a minimum.

The Contractor shall submit detailed schedule/manual of all O&M activities and contents with references of equipment manufacturer's maintenance schedules/manuals to the Employer for review and approval.

The Contractor shall carry out all O&M activities as per the approved Operation and Maintenance Manuals, including updated and approved Manuals based on operation and maintenance experience.

During the Operation Service Period, the Contractor shall ensure that the stipulated design effluent standards and sludge quality are met in accordance with the specifications in the Bidding Document/Contract.

The Contractor's responsibility shall also include the safety and security of the Works / plants during the course of Operation and Maintenance.

During the Operation Service Period, the Contractor shall appoint a Plant Manager, Shift-in-charge, Plant Operators, Plant Chemists, Fitters/Mechanics, Electricians, Instrumentation and Control Technicians, gardeners/peons, watchman and helpers as required for the operation and maintenance of the Works/plants (TSPSs/ WwTPs) for three shifts and adequate other staff / supporting personnel during general shift.

Key and other O&M personnel shall have minimum qualification and experience as given below, which also shows the minimum number of staffs per designation at each WwTP and TSPS location:

16.1.1 Minimum Number of Staff per Designation and Qualifications Requirements during Operation Service Period for WwTPs/TSPSs/ISPSs

Designation	Minimum Qualifications and Experience	Shift			Total for One plant
		1	2	3	
Plant Manager	Should have a minimum of 10 years of relevant experience after completion of a Graduate/ Postgraduate in Public Health, or Environmental Engineering, or Sanitary Engineering, or Civil Engineering, or Process Engineering with specialization in wastewater collection and treatment, and having experience in WWTP and Sewage Pumping Stations Testing, Commissioning, Operation & Maintenance, Liaison with Government, Pollution Control Authorities. Shall have completed at least one advanced Wastewater Operations course or equivalent.	1 No for General Shift			1
Plant Operator cum Shift-In-Charge	Should have minimum 7 years of relevant experience after completion of Diploma in Civil, Public Health, or Environmental Engineering with specialization in wastewater collection and treatment. Shall have completed at least one	1	1	1	3

Designation	Minimum Qualifications and Experience	Shift			Total for One plant
		1	2	3	
	advanced Wastewater Operations course or equivalent.				
Plant Chemist	Should have minimum 3 years of experience after completion of Graduate in Environmental Science / Chemistry having experience in WWTP laboratory (sampling / analysis)/ operation and maintenance.	1 No for General Shift			1
Electrician	Should have minimum 3 years of experience after completion of Diploma/ ITI Certification in Electrical Engineering with experience in WWTP & TSPS Erection, Testing, Commissioning, and Operation & Maintenance.	2	2	1	5
Instrumentation and Control Technician	Should have minimum 4 years of experience after completion of Engineering / Diploma in Instrumentation and Control Engineering with experience in WWTP & TSPS Erection, Testing, Commissioning, and Operation & Maintenance including PLC/SCADA based system.	1	1	1	3
Fitter / Mechanic	Should have minimum 3 years of experience after completion Diploma / ITI Certification in Mechanical Engineering with experience in WWTP & TSPS Erection, Testing, Commissioning, and Operation & Maintenance.	2	2	1	5

Note:

a) *The above specified requirement is **Minimum for one WwTP**, Contractor shall provide specified minimum staff at WwTP location. Further, Contractor shall arrange extra work force, as and when required, so as to smoothly run the operation and maintenance including preventive maintenance, repairs etc. and general cleanliness of the installations.*

b) *The above staff strength is exclusive of leave reserve required for different category of staff. The Contractor shall ensure availability of the personnel given in the above table for all seven days in a week.*

c) *The Contractor shall provide minimum number of Helpers, Gardener/Sweeper and Watchmen for all other activities as defined to fulfill its obligations under the Contract during the O&M Period*

d) *The Contractor shall make appropriate arrangements for maintenance of items like road work, buildings, arboriculture, patrolling and maintenance of civil structures, vehicle operations and other activities as defined to fulfill its obligations under the Contract during the O&M Period*

e) *Employer may/might appoint one Plant Operator (General shifts) for WwTP in addition to Contractor's operational staff. Contractor should make Employer's Operator involved in all day-to-day Operation and Maintenance activities of WwTPs. Employer's Operator shall report to concerned Engineer from Employer and wages towards Employer's Operator shall be directly paid to Employer's Operator from Employer. Contractor shall make note that Employer's Operator is not authorized to certify any of the Contractor's monthly O&M bills; however, Employer's Operator responsibilities shall be similar to the responsibilities of Plant*

Designation	Minimum Qualifications and Experience	Shift			Total for One plant
		1	2	3	
In charge and/or Plant Manager. (Refer Part 15 of Tender Document).					

The Contractor shall furnish complete resumes/biodata to the Engineer for approval of all personnel proposed two months before the start of the Operation Service Period.

16.2 Health and Safety

S.No	Item	Description
1	Chlorination	- All personnel who are assigned to use chlorine shall first be trained to understand and follow all aspects of procedure and safety; Training shall include the potential hazards related to poor personal hygiene and unsanitary practices. - Chlorine handlers shall be instructed to report any condition that may affect their personal hygiene to their superiors.
2	Chemicals (Ploy/Alum/ NaOH)	- All personnel who are assigned to use chemicals shall first be trained to understand and follow all aspects of procedure and safety; Training shall include the potential hazards related to poor personal hygiene and unsanitary practices. - Chemical handlers shall be instructed to report any condition that may affect their personal hygiene to their superiors.
3	Electricity	- All the electrical equipment shall be handled and operated by a trained and authorized person only. All the equipment shall be checked for its proper earthing and loose connections prior to start the equipment. Naked wire, loose connections, and faulty connections shall be repaired immediately prior to the start of operation. - Electrical sockets and switches shall not be touched by bare or wet hands. If a live wire is found naked or on wet ground, the main switch shall be turned off first, and then the wire shall be repaired or moved. - For any electrical works, proper insulated tools shall be used. Do not try to use tools made for other purposes; it may be hazardous.
4	Fall protection	- Only authorized persons shall work at high places; people working at high levels shall be very careful and protect themselves from falls and injuries. Protective gear such as gloves and safety belts shall be worn, and safety belts shall be tied to a proper location prior to starting the work. If anybody feels dizzy and drowsy, they should not work at high altitudes and should come down immediately. - Wherever possible a ladder shall be used. Ladders shall be in stable condition, and the proper slope of the ladder is 4 vertical and 1 horizontal, and they shall be properly secured at the base. - All the openings shall be secured properly by barrier of handrail to avoid unauthorized person getting in. Wherever covers are provided

S.No	Item	Description
		for opening those covers shall keep closed all the time, except for maintenance time.
5	Entering inside tanks and other confined space entry including all unit process and pumping stations	- Special precaution shall be taken, if worker(s) enter inside manholes or tanks (especially deep manholes or tanks). Personal entering to the deep manholes or tank must possess complete Self-Contained Breathing Apparatus (SCBA). - Manholes cover shall be opened to allow fresh air to circulate. - Before entering any tank, the Methane and Hydrogen Sulphide levels inside the tank shall be checked; otherwise, it may be hazardous. If oxygen is not enough, a ventilating fan should be used to supply fresh air inside. - Only permitted persons shall work inside. While a person is working inside, there must be another person watching from outside; unless he appoints a replacement person, he should not leave his post. While men are working inside manholes, the manholes must be kept open and manholes shall be protected such that staffs whom the Contractor does not engage do not go inside the manhole. - If a person inside feels drowsy, dizzy or feel uneasy he should leave immediately. He should rest and take fresh air. - If the worker is collapsing inside, do not immediately enter inside to rescue him as you may be next victim of accident. Prior to rescue make sure that oxygen inside is sufficient and report immediately to the person in-charge. Try to rescue the person from outside.
6	Health check up	- Water can be scrapped and become a carrier of water borne disease if it is handled by an ill person. That's why personal health is an important factor to keep the water potable. Any person not feeling well shall report to their superior and go through proper health checkups. - All workers should go through medical checkup every year, and the result of checkup shall be reported to the Engineer. - Contractor shall organize Biannual health camps for all O&M workers
7	General personnel's cleaning	- Persons working on sewerage and sewage treatment shall maintain a high level of personal hygiene. This includes clean work clothes, skin, fingernails, and hair. They should wash their hands properly with soap and clean water prior to handle the sewerage works.
8	Uniform	- All workers at site work shall wear helmet, safety shoes, and regular uniform to avoid any accident by rotating equipment or by any other means including unforeseen events.
Notes: *Contractor shall prepare and submit the safety action plan 60 days prior for review and approval.*		

16.3 Definition of Maintenance

Maintenance covers all the techniques and systems which, by means of regular monitoring of equipment and scheduled maintenance procedures, prevent failures and, in the event of problems, enable repairs to be carried out with the minimum disruption of the process. Maintenance is therefore a combination of technical, administrative, and management activities. Maintenance consists of preventive, predictive and corrective procedures.

16.4 Preventive Maintenance

Preventive maintenance consists of all the regular work carried out in order to sustain the necessary conditions or smooth operation of the plant and to keep the performance of the equipment as close as possible to its original performance level. Its purpose is to reduce the probabilities of failure of deterioration of equipment of the plant. In simple terms, preventive maintenance involves elementary operations such as lubrication, mechanical servicing, electrical and instrumentation servicing.

16.5 Corrective or Remedial Maintenance

Corrective or remedial maintenance consists of all work needed to re-establish the conditions necessary for an apparatus or set of equipment to operate properly subsequent to failure or deterioration of the results produced by the equipment. It includes the following operations:

- Dismantling of equipment,
- Replacement of parts

The work may be scheduled for the short or medium term in accordance with the checks carried out as part of the preventive maintenance procedure, the number of hours an apparatus has been operating, or an alarm factor (abnormal noise, repeated cut-out, weakening of the insulation, etc), or may be dictated by an unexpected breakdown.

I. Maintenance work

The work consists of inspection work and maintenance work as mentioned below:

- Inspection work, that includes physical appearance, inspection and measurement with testing equipment to verify and survey whether the plant performance/operation is normal or not.
- The inspection work shall be executed daily by each technical specialist as a routine and/or regular inspection and shall be recorded and trended each and every time. The evaluation of the collected data shall be immediately reviewed by the Plant Manager/Shift-in-charge to instruct the staff member for operation on the same day and/or make a plan of detail inspection and/or make repair schedule to make sure continuous plant operation without any problem.
- Maintenance work, for which main task-work shall include activities, such as lubrication, overhaul, replacement of parts, repair, adjustment, detail examination and test, cleaning, to maintain the plant in a good condition, performance consistent and low-cost operation based on a regular and preventive maintenance schedule including attending sudden equipment breakdown and to achieve high operational efficiency.

II. Operation work

This work consists of operation work and monitoring work:

- Operation work is executing the plant operation based on the scheduled process and procedure to meet designed criteria including set-up or adjust the operational index or data according to the water quality or demand.
- Monitoring work is to confirm the operation data, readout its measurement value on panels, and check-up the working performance of plant appropriately, as well as keep the records of the output.

- Prepare and present running trend graphics, for use in process adjustment and optimization of power and chemical consumption.

16.6 Material Specifications

The specification of materials used for repairs shall be the same as have been used in the original work. Specifications for any materials which were not used during construction shall be approved by the Engineer prior to commencement of the operation and maintenance period and must be incorporated in the O&M Manual. Without being limited by this clause, during the Operation Service Period the Contractor shall use appropriate material for repairs even if material required for such repairs has not been approved earlier, and no delay in making such repairs shall be subjected to such limitation. However, subsequent to use of such material the Contractor shall submit proposals for the approval of specifications of such material. The approved material will subsequently form a part of the O&M Manual. The comprehensive information as detailed in below Table shall be submitted to the Engineer.

List of Execution Schedule:

Items	Description
Maintenance of plant/ facilities	List of unit processes, Capacity of equipment's, Method/ Frequency of maintenance.
Operation of plant/facilities	List of plant/equipment, Items to be monitored/operation procedures, Preparation of chemical, handling sludge, Method of system control and its note, how to input data into computer, operation of backup, Period of Power failure and generator operation, communication method.
Monitoring of effluent quality and reporting	Scope of monitoring, Method of sampling and analysis, Place of laboratory and name of authorized personnel.
Countermeasure against accident and risk management	Damage prediction, Simulation of public relations, Method of recovery, Contact address, Rescue activity and emergency team.
Renewal	Replacement of pipes, Replacement of equipment & Facilities.
Subcontracting	Method of contract out, Scope of works, limit of responsibility.
Evaluation & Report	Method of data analysis, Evaluation of collected data, Improvement program, Reporting.
Organization and administration	Executive organization chart, Structured communication plan, Segregation of duties, List of staff member, Experience, Health certificate of staff member, type of insurance, Criminal record, Personnel name of taking record and make soft data, method of data control, Operation and maintenance cost.

16.7 Typical Mechanical Items & Maintenance Requirements (TSPS)

The main items of preventive maintenance work are shown below.

Name of Facility	Daily	Periodic	
	Point to be checked	**Frequency**	**Point to be checked**
Motorised Gates	- Check Smooth-Operation - Check safety equipment	Weekly	- Check oil levels and Greases - Smoothness of operation (Fully open & Close)
		Monthly	- Check opening-and-closing time
Wet well, Channels and Chamber	- Removal of floating matter - Check of water level	As needed basis	- Cleaning of sediment - Check H_2S gas concentration
Screens	- Check Smooth-Operation - Check of the difference of the water level before and behind a screen - Remove un-removable floating matter on screens - Clean-up drop garbage - Clean-up Top of Screen - Check abnormal noise - Check safety equipment - Check manual cleaning equipment Correctness	As needed basis	- Adjustment of take-up for Drive chain - Check Screen- shape - Check Operation of a wiper - Adjustment of space between rakes and a screen - Check of the lubricating oil level of reduction gears - Check Rake-speed - Check emergency stop system
Screening Conveyor	- Check Smooth-Operation- - Abnormal noise - Check screw-performance - Cleaning of Conveyor - Check safety equipment	Weekly	- Grease up & Oil - Check emergency stop system
		Monthly	- Check Damage to a screw - Check Slack of a screw adjustment of take-up - Check of an emergency shutdown system - Check screw speed
Submersible Pumps	- Check Smooth-Operation - Check discharge rate, pressure, abnormal noise, Vibration - Checkup minimum submergence in wet well - Check safety equipment - Position of valve	Monthly	- Check pump damage - Check the pump lifting equipment for performance and smoothness
		Every 6 Months	- Check wear on pump impeller - Check Oil level and grease up - Check bearings
		Every 1~3 Year	- Check pump performance & wear on pump impeller

Name of Facility	Daily	Periodic	
	Point to be checked	**Frequency**	**Point to be checked**
Motorized Monorail Hoist	- Check Smooth-Operation - Check all lifting equipment including wire and hook - Check lifting and traveling performance. - Check safety equipment	Monthly	- Check End-stop system
		As needed basis	- Check traveling speed - Check hoist rails, structure & support - Check deflection of girder
Valves	- Check water leakage	As needed basis	- Check seal - Check damage

16.8 Typical Mechanical Items & Maintenance Requirements (WwTP)

The main items of preventive maintenance work are shown below.

Name of Facility	Daily	Periodic	
	Point to be checked	**Frequency**	**Point to be checked**
HEAD WORKS/FINE SCREEN INLET CHANNELS			
Screens	- Check Smooth-Operation - Check of the difference of the water level before and behind a screen - Remove un-removable floating matter on screens - Clean-up Top of Screen - Check abnormal noise - Check safety equipment - Check manual cleaning equipment Correctness	As needed basis	- Check Screen-shape - Operation of a wiper - Adjustment of space between rakes and a screen - Check of the lubricating oil level of reduction gears - Check emergency stop system
Screenings Conveyor	- Check Smooth-Operation- - Abnormal noise - Check screw-performance - Cleaning of Conveyor - Check safety equipment	Weekly	- Check Grease up & Oils - Check emergency stop system
		Monthly	- Check Damage to a screw - Check Slack of a screw adjustment of take-up - Check of an emergency shutdown system - Check screw speed
HEAD WORKS/GRIT CHAMBERS			
Vortex Grit Collectors	- Abnormal noise - Check Smooth-Operation - Check safety equipment	Weekly	- Check grease up & Oil level of reduction gears - Remove scum& cleaning - Check emergency stop system

Name of Facility	Daily	Periodic	
	Point to be checked	**Frequency**	**Point to be checked**
		Every 6 Months	- Check of shaft rotation speed
		Yearly	- Dry basins for checking of damage, vortex velocity, repair, painting & cleaning
Slurry Pumps for Vortex Grit Chamber	- Check Smooth-Operation - Check discharge rate, pressure, abnormal noise, heat &vibration - Check liquid leakage - Check pump rotation direction - Check safety equipment	Monthly	- Clean up with water
		Every 6 Months	- Check pump damage -Check wear of pump impeller
		Every 1~3 Year	- Check pump performance & wear on pump impeller
Grit Classifier Equipment for Vortex Grit Chamber	- Check Smooth-Operation - Check discharge rate, abnormal noise - Check liquid leakage - Check safety equipment	Weekly	- Check grease & Oil level of reduction gear box - Remove scum &cleaning - Clean up with water
		Monthly	- Check emergency stop system
		Every 6 Months	- Check of shaft speed - Check for damages
ANAEROBIC/ANOXIC ZONE			
Anaerobic Tank Mixers	- Check mixing condition in the zone - Check abnormal noise - Check safety equipment	Every 6 Months	- Check the mixer lifting equipment for performance and smoothness - Check Mixer damage - Clean with water
		Yearly	- Check smoothness of mixer operation - Check mixer impeller wear - Check Mixer speed &rotation direction
AERATION ZONES			
Air Diffusers Assembly	- Check mixing condition in the zone - Check air flow rate & pressure	Every 6 Months	- Check the diffuser lifting equipment for performance and smoothness - Check diffusers Assembly
		As needed basis	- Check the air flow rate and size of air bubble - Check diffuser performance

Name of Facility	Daily	Periodic	
	Point to be checked	**Frequency**	**Point to be checked**
			- Chemical cleaning for diffusers - Remove deposited material between diffuser and basin floor
Recycle Pumps	- Check Smooth-Operation - Check discharge rate, pressure, abnormal noise - Check safety equipment	Monthly	- Check pump damage - Check the pump lifting equipment for performance and smoothness - Cleaning up with water
		Every 6 Months	- Check wear of pump impeller - Pump speed & rotation direction
		Every 1~3 Year	- Check pump performance
Monorail Motorized Hoist	- Check Smooth-Operation - Check all lifting equipment including wire and hook - Check lifting and traveling performance - Check safety equipment	Monthly	- Check End-stop system
		As needed basis	- Check traveling speed - Check hoist rails, structure & support
EOT Crane/Hoist	- Check Smooth-Operation - Check all lifting equipment including wire and hook - Check lifting and traveling performance - Check abnormal noise & vibration - Check safety equipment	Monthly	Check End-stop system
		As needed basis	- Check traveling speed - Check rails, structure & support Check any damage
Scum Removal	- Check Smooth-Operation - Check performance of scum trough - Check safety equipment	Weekly	- Remove un-skimmed scum - Cleaning scum trough up
		Every 6 Months	- Adjustment of scum skimmer level
		Every 1~3 Years	- Check damage, repair, paint & cleaning with water
Decanters (Over flow weir)	- Check overflow weir and water level - Check smooth performance of motored overflow weir control	Daily	- Smooth discharge and stable overflow from decanters - Smooth Sludge drain process

Name of Facility	Daily	Periodic	
	Point to be checked	**Frequency**	**Point to be checked**
	- Check Decanters up-and down movement/ smoothness - Check decanter supports strength and floating stability during mixing process		
PROCESS AIR BLOWER BUILDING			
Air Blowers	- Check Smooth-Operation - Check discharge rate, pressure, abnormal noise, heat and vibration - Check blower speed & rotation direction - Check coupling connection - Check cooling system - Check air leakage - Check safety equipment	Weekly	- Check grease up & Oil level of reduction gear box - Check safety equipment - Check Air filter - Check drain
		Every 1~3 Year	- Check Blower performance
		As needed basis	- Check blower system - Check Silencers
EOT Crane/Hoist	- Check Smooth-Operation - Check all lifting equipment including wire and hook - Check lifting and traveling performance - Check abnormal noise & vibration - Check safety equipment	Monthly	- Check End-stop system
		As needed basis	- Check traveling speed - Check rails, structure & support - Check any damage
Alum Mixer	- Check coagulation condition - Check abnormal noise & vibration - Check safety equipment	Every 6 Months	- Check the mixer lifting equipment for performance and smoothness - Check Mixer damage
		Yearly	- Check smoothness of mixer operation - Check mixer speed & performance
CHEMICAL BUILDING (Alum Building)			
Alum Solution Tanks	- Check corrosion condition - Check leakage - Check drain & Overflow pipe	Weekly	- Remove deposition substance - Clean up tank & touch-up painting
	- Check Smooth-Operation	Weekly	- Clean up mixer

Name of Facility	Daily	Periodic	
	Point to be checked	**Frequency**	**Point to be checked**
Alum Solution Tank Mixers	- Check abnormal noise& vibration - Check mixing time - Check safety equipment	Monthly	- Check mixing speed - Check shaft and coupling connection
Alum Dosing Pumps	- Check Smooth-Operation - Check discharge rate, pressure, abnormal noise, heat and vibration - Check safety equipment	Monthly	- Check accuracy of flow rate through calibration - Clean up with water
		Every 1~3 Years	- Check pump performance
Flow Indicator	- Check flow indicator - Check safety equipment	Weekly	- Check accuracy of flow rate - Clean up with water
Monorail Motorized Hoist	- Check Smooth-Operation - Check all lifting equipment including wire and hook - Check lifting and travelling performance - Check safety equipment	Monthly	- Check End-stop system
		As needed basis	- Check travelling speed - Check hoist rails, structure & support
SCUM PUMP PIT			
Scum Pumps	- Check Smooth-Operation - Check discharge rate, pressure, abnormal noise - Check safety equipment	Monthly	- Check pump damage - Check the pump lifting equipment for performance and smoothness - Cleaning up with water
		Every 6 Months	- Check wear on pump impeller - Pump speed & rotation direction
		Every 1~3 Years	- Check pump performance
DISC FILTERS			
Disc Filters	- Check Smooth-Operation - Check of the difference of the water level before and behind a disc filter's - Remove un-removable floating matter on filter - Clean-up Top of filters - Check backwash flow rate - Check inlet and outlet Turbidity	Monthly	- Check Damage to Filter media - Check Slack of a disc & adjustment of take-up - Check Disc speed
		Every 1~3 Years	- Check backwash pump performance - Replace damaged disc filters

Name of Facility	Daily	Periodic	
	Point to be checked	**Frequency**	**Point to be checked**
	- Check safety equipment		
CHLORINE CONTACT TANK INLET CHANNEL			
Motored Chlorine Injectors (In-line)	- Check Smooth-Operation - Check motor running - Check Chorine residual in chlorine contact tank - Check abnormal noise & vibration	Weekly	- Check damage of chlorine gas supply line - Check backflow prevention valve - Check leakage of chlorine solution
	- Check chlorine gas leakage by ammonia liquor - Check Gas pressure gauge, vacuum gauge, gas flow meter - Check safety equipment	Yearly	- Check the injector maintenance lifting equipment for performance - Check in-line injector performance and smoothness
CHLORINE BUILDING			
Chlorinators	- Check solution leakage and/or chlorine gas - Check Gas pressure gauge, gas flow meter - Check dosing rate/amount - Check chlorine gas rate valves, check valves& pipeline - Check safety equipment	Weekly	- Check total System
Chorine Cylinders (Ton)	- Check chlorine gas / solution leakage - Check no gas leakage, and no wet or keep dry in the room - Check room temperature & humidity - Check Gas header, pipeline& gasket - Check safety equipment	Weekly	- Check Condition of the cylinder-material and Safety valve - Check storage way - Classification of cylinder as new or empty, and check the stock - Cleaning
Cylinder Scales	- -Cleaning weight area	Weekly	- Check measuring error
Cylinder Lifting Equipment& Hoist	- Check Smooth-Operation - Check lifting equipment - Check lifting and travelling performance - Check safety equipment	Monthly	- Check End-stop system
		As needed basis	- Check travelling speed - Check hoist rails, structure & support

Name of Facility	Daily	Periodic	
	Point to be checked	**Frequency**	**Point to be checked**
Safety Equipment	- Check performance of chlorine gas detectors and sensors, Ventilation system - Check sequence of Auto / manual mode - Check safety equipment	Weekly	- Clean gas detector & sensors - Clean up the area installed detectors - Check safety shower performance
		Monthly	- Try-on oxygen mask, other safety appurtenances - Check Gas Leakage Repair Kits
Neutralization Equipment (Emergency Chlorine Scrubber)	- Check NaOH solution leakage from the tank /equipment /pipe/ valves - Check solution level-Check performance of splays, pumps - Check performance of exhaust blower - Check safety equipment	Weekly	- Check pH of NaOH solution
TREATED WATER PUMP STATION			
Submersible Pumps	- Check Smooth-Operation - Check discharge rate, pressure, abnormal noise - Check safety equipment	Monthly	- Check pump damage - Check the pump lifting equipment for performance and smoothness - Clean up with water
		Every 6 Months	- Check wear on pump impeller - Pump speed & rotation direction
		Every 1~3 Years	- Check pump performance
Monorail Motorized Hoist	- Check Smooth-Operation - Check all lifting equipment including wire and hook - Check lifting and travelling performance - Check safety equipment	Monthly	- Check End-stop system
		As needed basis	- Check travelling speed - Check hoist rails, structure & support
PLANT DRAIN PUMPING STATION			
Pumps	- Check Smooth-Operation - Check discharge rate, pressure, abnormal noise	Monthly	- Check pump damage - Check the pump lifting equipment for performance and smoothness

Name of Facility	Daily	Periodic	
	Point to be checked	**Frequency**	**Point to be checked**
	- Check safety equipment		- Clean up with water
		Every 6 Months	- Check wear on pump impeller - Pump speed & rotation direction
		Every 1~3 Years	- Check pump performance
SLUDGE DEWATERING BULDING			
Centrifuge Feed Pumps	- Check Smooth-Operation - Check discharge rate, pressure, abnormal noise, bearing temperature & vibration - Check feeding rate to meet speed of dewatering equipment - Check sludge leakage - Check safety equipment	Weekly	- Check grease up & Oil level of reduction gear box - Check safety equipment - Clean-up with water
		As needed basis	- Check pump performance
Dewatering Centrifuges	- Check Smooth-Operation - Check pressure, abnormal noise, bearing temperature& vibration - Check feeding sludge concentration and ratio of Polymer dosing - Check cake moisture and G-value - Check SS in drain - Check emergency stop system - Check no liquids leakage from casing, loose bolts/Nuts/tighten - Check grease up & Oil level of reduction gear box - Check safety equipment	Monthly	- Check quality of oil in reduction gear box - Check all safety equipment - Clean-up drain pipe of separate liquid
		Every 1~3 Years	- Check dewatering centrifuge performance
		As needed basis	- Check dewatering centrifuge system - Check space between screw and casing
Sludge Conveyor	- Check Smooth-Operation- - Abnormal noise	Weekly	- Check Grease up & Oils - Check emergency stop system

Name of Facility	Daily	Periodic	
	Point to be checked	**Frequency**	**Point to be checked**
	- Check screw-performance - Cleaning of Conveyor - Check safety equipment	Monthly	- Check Damage to a screw - Check Slack of a screw adjustment of take-up - Check of an emergency shutdown system - Check screw speed
Cake Hopper	- Check Smooth-Operation - Check abnormal noise& vibration - Check gate operation on opening and closing - Check liquid leakage - Check no cake on sludge bridge - Amount of cake sludge - Check safety equipment	Weekly	- Check grease up & Oils - Check gate performance - Check position of liquid trough - Check safety equipment
		As needed basis	- Check cake hopper assembly
Powder Polymer Storage Hopper	- Check Smooth-Operation - Check abnormal noise & vibration - Check polymer bridge - Check safety equipment	Weekly	- Check grease up & Oils - Cleaning dust off
		As needed basis	- Check powder polymer storage hopper assembly
Auto Feeder	- Check Smooth-Operation - Check abnormal noise &vibration - Check feeding rate - Clean-up feeder	Weekly	- Check feeding accuracy - Clean up feeder
		As needed basis	- Check the feeder performance
Polymer Tanks	- Check corrosion condition - Check leakage - Check drain & Overflow pipe	Weekly	- Remove deposition substance - Clean up tank & touch-up painting
Polymer Mixers	- Check Smooth-Operation	Weekly	- Clean up mixer
	- Check abnormal noise& vibration - Check mixing time - Check safety equipment	Monthly	- Check mixing speed - Check shaft and coupling connection
Polymer Feeding Pumps	- Check Smooth-Operation - Check discharge rate,	Monthly	- Check accuracy of flow rate - Clean up with water

Name of Facility	Daily	Periodic	
	Point to be checked	**Frequency**	**Point to be checked**
	pressure, abnormal noise and vibration - Check safety equipment	Every 1~3 Year	- Check pump performance
Motorized Monorail Hoist	- Check Smooth-Operation - Check all lifting equipment including wire and hook - Check lifting and traveling performance - Check safety equipment	Monthly	- Check End-stop system
		As needed basis	- Check traveling speed - Check hoist rails, structure & support
BIOGAS PIPELINE			
Biogas pipeline	-Check flow rate -Check pipeline damage -Check gas leakage -Check safety equipment against any kind of accident -Check demister performance -Check drain equipment -Check drain pit damage	Weekly	-Check Biogas pipeline assembly -Check Gas component
BIOGAS SCRUBEBER AREA			
Gas Blowers (feeding to scrubber)	-Check Smooth-Operation -Check discharge rate, pressure, abnormal noise, heat and vibration -Check blower speed -Check coupling connection -Check filter & demister -Check Gas leakage -Check safety equipment against any kind of accident	Weekly	-Check grease up & Oil level of reduction gear box -Check filter & demister -Check drain
		Every 1~3 Year	-Check Blower performance
		As needed basis	-Check blower & safety system -Check Silencers

Name of Facility	Daily	Periodic	
	Point to be checked	**Frequency**	**Point to be checked**
Scrubber (Automaticall y operation) w/Mas-Packs	-Check feeding Gas rate -Check No Gas leakage & No chemical leakage -Check sufficient contact time with Gas and water / chemical -Check NaOH concentration value in buffer tank -Check water level at water tank level and NaOH solution level at buffer tank -Check Gas H_2S concentration value at scrubber inlet and outlet -Check crystal generation through observation door -Check all pumps performance -Check safety equipment against any kind of accident -Check wear/use a safe instrument for handling NaOH solution -Check safety equipment performance.	Weekly	-Remove crystal on the media -Remove crystal in NaOH buffer tank -Remove crystal in pipe line valves, spray nozzles and strainers -Check NaOH leakage from dosing tank -Check NaOH mixer performance -Cleaning water spray nozzles -Cleaning mist elimination equipment -Handling the crystal to off-site
		Monthly	-Check NaOH storage yard -Check safety instrument
		As needed basis	-Check Biogas scrubber system including safety instrument
CLEAN BIOGAS BLOWER			
Biogas Blowers	-Check Smooth-Operation -Check discharge rate, pressure, abnormal noise, heat and vibration -Check blower speed -Check coupling connection -Check filter & demister -Check Gas leakage -Check safety equipment against any kind of accident	Weekly	-Check grease up & Oil level of reduction gear box -Check filter & demister -Check drain
		Every 1~3 Year	-Check Blower performance
		As needed basis	-Check blower & safety system -Check Silencers
BIOGAS FLARE FOUNDATION			
BIOGAS Flare	-Check Stable combustion -Check feeding rate	Weekly	-Check flaming gas to comply with emission control standard

Name of Facility	Daily	Periodic	
	Point to be checked	**Frequency**	**Point to be checked**
	-Check automatic ignition equipment -Check Gas-supply-emergency shutoff valve performance -Check safety equipment against any kind of accident -Check air supply blower performance	As needed basis	-Check Flare equipment & safety system -Check Silencers
GAS GENERATION SET ROOM			
Biogas Engine (If applicable)	-Check Smooth-Operation -Check engine speed, abnormal noise, heat and vibration -Check Engine temperature -Check Jacket water temperature -Check engine Oil system -Check emergency jacket water cooling system -Check Starter performance -Check engine emergency stop system -Check Gas leakage -Check Gas safety equipment against any kind of accident	Weekly and As needed basis	-Check gas component -Check exhaust fume component for emission standard -Check noise level & Silencers -Check pollution control device of engine exhaust -Check filters
		Recommended by Manufacture	-Replace filters/Oil -Check sparkplug -Replace spark plug -Adjustment of carburettor -Replace cylinders -Overhaul -Others
Heat Exchanger (Hot Jacket water/ exhaust fume)	-Check loss head, flow rate -Check heat exchanger effectiveness -Check water temperature at inlet and outlet of heat exchanger -Water leakage -Check color in the hot water pipeline	As needed	-Remove adherent scale on double tube of heat exchanger -De-aeration -Check gauge accuracy -Clean up heat exchanger
		Every 1~3 Year	-Check heat exchanger performance

Name of Facility	Daily	Periodic	
	Point to be checked	**Frequency**	**Point to be checked**
	-Check safety equipment against any kind of accident		
BOILER BUILDING			
Hot Water Boilers (Dual fuel :GAS/Oil)	-Check feed water temperature at inlet and outlet -Check burner flame -Check Steam generation pressure, flue gas temperature. -Check boiler & system for leak		-check burner operation -Inspect Refraction -flush boiler with water to remove scale & Sediments -Clean burner & burner pilot - Clean air damper -Manually lift safety valve by hand -Inspect combustion control system -Recalibration of all indicating instruments & record gauges -Check formation of scale, soot
Hot Water Circulation Pumps	-Check Smooth-Operation -Check discharge rate, pressure, abnormal noise, heat and vibration -Check hot temperature -Water leakage -Check safety equipment against any kind of accident	As needed basis	-Remove adherent scale in pump & Pipeline -Remove air in the system -Check pump impeller -Check flow rate
		Every 1~3 Year	-Check pump performance -Wear on Impeller
PRIMARY CLARIFIERS			
Clarifiers (Trolley Wheels, Reduction Gear box, Plate mechanism, Rail/ Track, Reduction gear, Scrappers, mechanism)	-Abnormal noise -Check Smooth-Operation -Check safety equipment	Weekly	-Check grease up & Oil level of reduction gears tapping of oil level. -Remove scum & cleaning -Clean algae on overflow weir, trough and wall
		Monthly	-Check emergency stop system
		Every 6 Months	-Check peripheral velocity -Adjustment of shaft rotation speed, checking of carbon brushes, bearing of motor etc.
		Yearly	-Dry basins for checking of damage, space between rake and bottom floor, repair, paint

Name of Facility	Daily	Periodic	
	Point to be checked	**Frequency**	**Point to be checked**
			& cleaning, tightening of nut & bolts, replacement of broken parts, checking of wear & tear alignment & its positioning
Scum Skimmer	-Check Smooth-Operation -Check performance of scum skimmer & scum trough	Weekly	-Remove un-skimmed scum -Cleaning scum trough up
		Every 6 Months	-Adjustment of scum skimmer level
		Yearly	-Check damage, repair, paint & cleaning
PRIMARY SLUDGE PUMP STAION			
Primary Sludge Pumps	-Check Smooth-Operation -Check discharge rate, pressure, abnormal noise, heat and vibration -Check sludge leakage -Check pump speed & rotation direction -Check safety equipment	Weekly	-Check grease up & Oil level of reduction gear box
		Every 6 Months	-Check pump damage -Check wear of pump impeller -Check of pump speed-Clean up with water
		Every 1~3 Year	-Check pump performance
GRAVITY THICKENER			
Thickener	-Check Smooth-Operation-Abnormal noise -Removal scum -Check safety equipment	Weekly	-Check grease up & Oil level of reduction gears -Remove scum& cleaning -Clean algae on overflow weir, trough and wall -Clean up with water
		Monthly	-Check emergency stop system
		Every 6 Months	-Check peripheral velocity -Adjustment of shaft rotation speed
		Yearly	-Dry basins for checking of damage, space between rake and bottom floor, repair, paint & cleaning
THICKENED SLUDGE PUMPING STATION			
Thickened Sludge Pumps	-Check Smooth-Operation	Weekly	-Clean up with water
		Every 6 Months	-Check pump rotor -Check flow rate

Name of Facility	Daily	Periodic	
	Point to be checked	**Frequency**	**Point to be checked**
	-Check discharge rate, pressure, abnormal noise, heat and vibration -Sludge leakage -Check safety equipment	Every 1~3 Year	-Check pump performance

16.9 Typical Electrical Items & Maintenance Requirements

Daily		Periodic	
Frequency	**Description**	**Frequency**	**Description**
Transformer	- Verification of KVA, V, A, - abnormal sound, current protection, oil temperature	Every 6 Months	- Verification of general performance, verification of oil levels, silica gel in breather, OLTC, OTI, WTI, Buchholz relay, CTs etc ,testing of oil, verification of earth connections, IR measurement.
11 kV Switchboard and Switchgears	- Verification of kVA, kW, kWh, V. - A, PF, Hz, healthiness of protections, indications. - Alarms, abnormal sound, burning. - Smell.	Every 6 Months	- Verification of condition of breakers, switches, relays, protective devices, earthing, wiring and connections.
PCC /MCCs/MLDB	- Verification of V, A, healthiness of protections, lamps, abnormal sound, burning smell	Every 6 Months	- Verification of condition of breakers, switches, pushbuttons, relays, protective devices, earthing, wiring and connections
Variable Frequency Drives	- Verification of Input & output voltage, current, frequency. - Verification of Indications, alarm & protections.	Every 6 Months	- Verification of condition of breakers, switches, pushbuttons, relays, protective devices, earthing, wiring and connections. - Verification of working of converter, inverter, DC Link. - Verification of Harmonic Distortion.
Lighting panels	- Verification of lamps, abnormal sound, burning smell.	Every 6 Months	- Verification of condition of breakers, switches, earthing, wiring and connections.

Daily		Periodic	
Frequency	**Description**	**Frequency**	**Description**
Meters reading	- Verification of V, Am, overload protection	Every 6 Months	- Verification of over load protection indication, switch On/Off, accuracy, damage
Diesel Generator Set	- Verification of Engine oil level, Engine oil leakage, air & oil filters, cooling fans, fuel level, water level etc. - Verification of battery voltage, charging & self-start. - Verification of abnormal sound, vibrations etc. - Verification of Voltage, current, frequency, RPM, Indications, Alarms & Protections. - Verification of Oil leakage, fuel leakage. - Verification of Interconnecting Cable, earthing, loose connections etc.	Every 250 hours/6 Months	- Verification of Conditions of filters. - Verification of Condition of cooling fan. - Verification of Condition of battery & charger. - Verification of self-start system - Verification of condition of engine, alternator & accessories, doors of acoustic enclosure, exhaust system etc. - Verification of conditions of Breakers, Switches, Push Buttons, Relays etc. - Verification of Auto / Manual operation, all interlocks, synchronizing. - Verification of Indications, Alarms & Protections. - Verification of Condition of Interconnecting Cables, Connection & earthing, including Neutral Earthing of AC Generator.
Cable system	- Verification of short circuit, burning smell, loose connections, local heating.	Every 6 Months	- Verification of voltage drop, damage, insulation resistance
Lighting Fixtures	- Verification of working of lamps & ballasts.	Every 6 Months	- Verification of illumination level - Verification of condition of lamps & ballasts. - Cleaning of lighting fixtures. - Verification of wiring.
Switch board	- Verification of operation of switches, sockets.	Every 6 Months	- Verification of condition of switches, sockets & fan regulators. - Verification of wiring.

Daily		Periodic	
Frequency	**Description**	**Frequency**	**Description**
Switch Socket	- Verification of operation of Switch & Socket.	Every 6 Months	- Verification of condition of Switch & Sockets
Ceiling Fan	- Verification of operation of Fan.	Every 6 Months	- Verification of condition of ceiling fan. - Verification of condition of bearing, abnormal sound /noise.
Power sockets	- Verification of operation of MCB, Plug & Socket.	Every 6 Months	- Verification of condition of MCB, Socket & Wiring.
General	- Inspection of General appearance of various Electrical equipment /items. - Verification of Cable System for Short circuit, smell, damage etc.	Every 6 Months	- Verification of condition of cables, wires& connections. - Verification of Insulation resistance of individual equipment, cables and total system. - Verification of Condition of Earth Connections.

16.10 Electrical System Operation Practices

All the electrical equipment's shall be handled and operated by a trained and authorized person only. All the equipment shall be checked for its proper earthing and loose connections prior to start the equipment. Naked wire, loose connections and faulty connections shall be repaired immediately prior to start for operation.

Electrical sockets and switch shall not be touched by bare or wet hands. If there is any live wire found naked or on wet ground, main switch shall be turned off first then the wire shall be repaired or moved.

For any electrical works proper, insulated tools shall be used. Do not try to use tools made for other purpose; it may be hazardous.

16.11 Maintenance Practices - Instrumentation, Control & Automation

16.11.1 General Maintenance

A comprehensive maintenance program is crucial for achieving long-term, reliable performance of SCADA systems and ICA systems. Periodic device calibration, preventive maintenance, and testing enable the identification of potential problems before they can cause mission failure. Prompt corrective maintenance assures reliability by minimizing downtime of redundant components.

The Contractor shall enter into AMC contracts with system/equipment suppliers of ICA, as necessary. It is mandatory for the Contractor to agree to a 10 (Ten) years operation and maintenance contract with the instrumentation, PLC and SCADA system supplier and wireless communication supplier or the authorized system integrator, whosoever has executed the work for this Contract.

16.11.2 Preventive Maintenance

The SCADA system should be part of the overall preventive maintenance (PM) program for the facility. Table below provides a list of recommended maintenance activities and frequencies for ICA systems & their components. Preventive maintenance schedules for ICA components and subsystems should be

coordinated with those for the mechanical/electrical systems they serve to minimize overall scheduled down time.

Activity	Frequency
Pneumatic Systems/Components/Instruments	
Check Regulators and Filters	Monthly
Inspect Tubing and Piping	Monthly
Actuate Pressure Switches	3 months
Calibrate Switches and Sensors	Yearly
Calibrate Pressure Gauges	Yearly
Calibrate Level Transmitters	Yearly
Calibrate Flow transmitters	Yearly
Calibrate Pressure Transmitters	Yearly
Calibrate Thermometers	Yearly
Calibrate Analytical Instruments/Online Instruments (pH, ORP, Turbidity, etc,)	6 Months
Change Sampling solution of Analytical Instruments	As required
Electronic Systems	
Lamp Test/Verify Indicators	Monthly
Inspect Enclosures for Dirt, Water, Heat	Monthly
Run PLC Diagnostics	3 Months
Calibrate Sensors and Transmitters	Yearly
Calibrate Meters	Yearly
PLC Communication Modules	Monthly
PLC Batteries	Yearly
Test Automatic control Sequences	Monthly
Verify Alarms	Weekly
Software Maintenance and Patching	3months
Anti-virus Definition Updates	Monthly
Inspect Wire, Cable and Connections	Monthly
Inter site Communication Network	Weekly
Dead Bus Relays	3 Months
UPS setting with SCADA	Weekly
PLC Redundant Power back up	Monthly
SCADA Redundancy	Monthly
Network Redundancy	Weekly
PLC Hot-Standby	Monthly
Historian Package (Capacity)	Monthly

Activity	Frequency
Data Archiving	Monthly

Notes:

a) *Many components of SCADA systems, such as dead-bus relays, are not required to function under, Normal system operating modes. For this reason, the system should be tested periodically under actual or simulated contingency conditions. These tests should approach as closely as possible the actual off Normal conditions in which the system must operate, For example, SCADA for Dual Redundant system should be tested by interrupting the utility source as far upstream of the normal service as possible.*

b) *Periodic system testing procedures can duplicate or be derived from the functional performance testing procedures.*

c) *The SCADA software maintenance should include timely updates of any new versions from the supplier and testing to verify proper installation on the SCADA computer. In addition, software antivirus updates should be maintained. This should be performed any time after the computer is connected to the Internet or the antivirus patch should be downloaded as and when the updates are available. Normal operation requires that the SCADA computer not be connected to the Internet.*

d) *Faulty Instruments, sensors, transmitters, communication modules, computer hardware should be replaced with new components. Repair of the items would not be accepted.*

16.11.3 Concurrent Maintenance

Concurrent maintenance is defined as testing, troubleshooting, repair or replacement of a component or subsystem while redundant component(s) or subsystem(s) are serving the load. The ability to perform concurrent maintenance is crucial for achieving the specified reliability and availability criteria for facilities and must be built into the SCADA system. Where SCADA components are associated with equipment that has redundancy and therefore are not redundant themselves, their maintenance should be scheduled to coincide with the maintenance of the associated equipment. SCADA components and controllers that are redundant must be capable of being taken out of service, repaired or replaced and tested without interfering with the operation of the redundant component.

16.11.4 Reliability-Centered Maintenance

Reliability-Centered Maintenance (RCM) is an approach for developing an effective and efficient maintenance program based on the reliability characteristics of the constituent parts and subsystems, economics, and safety. RCM provides a logical, structured framework for determining the optimum mix of applicable and effective maintenance activities needed to sustain the operational reliability of systems and equipment while ensuring their safe and economical operation and support.

A significant by product of the application of SCADA systems to the control of facilities is the large amount of operational data made available through the trending and data storage features of the SCADA. This operational data can be used for automated performance monitoring of mechanical and electrical systems that can support an RCM approach.

16.11.5 Operations and Maintenance Documentation

The Contractor should perform the O&M analysis to determine the O&M data required to support maintenance of the SCADA system. This analysis should be coordinated with Employer to determine maintenance parameters and O&M data that are available. Typical O&M data requirements include the following items:

a) System documentation as defined in FDS, FAT & SAT documents

b) Minimum spare parts list.

c) Recommended spare parts list.

d) Recommended onsite test equipment.

e) Recommended O&M training.

f) Recommended O&M to be performed by Contractor

16.11.6 Spare Parts Stocking

An adequate on-site stock of spare parts is essential to obtaining high availability of ICA systems.

All spare parts used for the equipment in the maintenance of the system must be from the manufacturer of the equipment or, if the equipment itself has been made with parts from other manufacturers, the parts must be of the same make as used in the equipment supplied and installed.

All spare parts shall be packed for long storage under the climatic conditions prevailing at the Site. Each spare part shall be labelled on the outside of its packing with its description, number and purpose and, if more than one spare is packed in a single case, a general description of the case contents shall be shown on the outside and a packing list enclosed.

Minimum recommended stocking levels include the following. These quantities may need to be increased for components which are used in large numbers in the facility:

1) Manufacturer's recommended spare parts list.
2) One each of all line replaceable boards or modules.
3) Six each power and control fuses used in the system.
4) Tools required to terminate coaxial on fiber optic cables.

Automation:

1) Laptop computer loaded with software required to access controllers.
2) Licenses for all software installed on the system.
3) Permission to modify program code.
4) Spare cables for connecting computer to controllers.
5) PLC CPU, Power supply module, DI, DO, AI, AO modules, Communication module, protocol converter etc.
6) PLC batteries, fuses, etc.
7) Utilities & Consumables
    a. The Contractor has to provide consumables for printers e.g.: Ink cartridges (color & B/W), A4, A3, A1 size of paper, printers for a period of 10 years.

Downtime of the above system should not exceed more than 2 hours.

16.11.7 Technical Support

The Contractor should specify functional areas of the operating system and/or equipment where a technical representative will be furnished by the manufacturer for training, test, checkout, validation, or pre-operational exercises.

Ongoing O&M of SCADA system software may require technical support from the system vendor or from agency technical personnel not located at the facility. Commercial SCADA software typically has provisions for remote modem access that permit this type of support from the vendor's location or an agency central engineering group. Such remote access provisions represent a vulnerability to "hacking" and must be used with great caution. They should be monitored when in use and physically disconnected when not in use.

Password protection policies for all SCADA systems, including PLC's, shall be in compliance with established policies and to be agreed with the Employer's Representative.

These policies require that the default password that came from the control supplier be changed when Placed into operation at the facility.

Note: -

1) During commissioning, Trial run and testing the Charges / Costs towards the following items shall be borne by the Contractor.
   - Network Operating charges for Wireless communication System (GPRS gateway)
   - Software updates, consumables, and stationeries etc.,
   - Instrumentation (Analog) & Control Cables and Power Cables, OFC, etc. If any required.
   - Painting for field Instrument enclosures.
2) During O&M Period:
   - Contractor shall Quote Network Operating charges for Wireless communication (GPRS gateway) yearly wise.

16.12 Annual Maintenance Contract

For all ICA works Contractor shall enter into an Annual Maintenance Contract (AMC) with system integrators, who have executed the works under this contract. The AMC shall include periodic maintenance of all Field instrumentation, analytical instrumentation, real time multi parameter Influent and effluent monitoring systems, lab equipment, Control, and automation system inclusive of PLC based SCADA system and wireless communication equipment. The AMC shall include periodic painting of all instrumentation enclosures, panels as required. The AMC shall also include supply of required spares and consumables as required for the complete ICA equipment throughout the O&M period. The Contractor shall depute trained personnel from the vendor for carrying out AMC tasks as required under this contract.

The Contractor is required to submit an AMC agreement with the system integrators (for Field instrumentation, analytical instrumentation, real time multi parameter Influent and effluent monitoring systems. Lab equipment, Control, and automation system inclusive of PLC based SCADA system and wireless communication equipment.) After the conduction of SAT and before applying for completion of Test on Completion certificate. The same shall be verified before issuance of test on completion certificate.

16.13 Prices for Operation and Maintenance

The Contractor, at the time of bidding, will be responsible to ensure the completeness and adequacy of his Bid Price to fulfil the entire responsibilities of Operation and Maintenance. Contractor bid price, as quoted on a yearly basis in the Schedule of Prices, shall include all costs for Operation and Maintenance.

16.14 Issue of Completion Certificate for Operation and Maintenance

Refer Part 17 for issue of completion certificate.

End of Part 16

PART 17

HANDING OVER

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PART 17

HANDING OVER

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PART 17

HANDING OVER

17.1 General

This section applies to procedure(s) on handing over the works and sites related to Wastewater Treatment Plant, Intermediate Sewage Pumping Station, and Terminal Sewage Pumping Station back to the Employer at the end of 10 years period of operation and maintenance by the Contractor. This shall include all civil structures, mechanical systems including pumping main system, the instrumentation/control & automation system, communication system, electrical system including 11kV/0.433kV substations, SCADA systems, all ancillary buildings and complete campus area.

The procedure for Handing Over shall include the final examination/tests of the system by the Engineer. O&M Contract Completion Certificate shall be issued by the Employer after the successful final examination/tests and submission of the relevant documents.

17.2 Duties and Responsibilities

1. All cost for the examination, tests, and preparation of any documents of the activities shall be the Contractor's responsibility.
2. The Contractor shall provide all necessary labour, materials, and fuel required for tests.
3. Conduct Joint Inspection Prior to Contract Completion:

   To verify the condition of Works / Facilities at the end of 10 years of operation and maintenance for identifying damaged works, replacements, and other works to be carried out to satisfy the requirements of Operation and Maintenance Plan, a joint inspection will be carried out by the Engineer, Employer and Contractor.
4. Conduct Tests prior to Contract Completion:

   To verify the plant condition and performance of plants including pumps, blowers, valves, gates, cranes and all other equipment at the end of 10 years of operation and maintenance, Contractor shall conduct all the required Tests prior to Contract Completion. The Contractor is responsible to conduct annual inspections of cranes & other lifting equipment, pressure vessels and other equipment as required by law/Govt. of Karnataka.

The inspection items are given below in Table 17. 1 but not limited to this.

Table 17. 1: Items to be examined at the end of 10 Years O&M Period

Items	Description
1) Appearance test /Visual examination (Damage/crack, differential settlement, soil settlement, peel off painting, missing/lost, leakage of water/solution/gas, corrosion, condition of structures, and others)	- All Civil structures, building including interior/exterior, fence/gate, stairs, others - All Mechanical & Electrical equipment/accessories, others - All Pipe line valves and gates, others - All Instrumentation and Control equipment, others
2) Performance examination (Selection of operation mode, selection of facilities, flow/water level, overflow, vibration/noise level, speed of pump/motor,	- Check Sequence, or Manual operation including water level, pressure sensors/protections, others - Check all Mechanical equipment including pressure and water level gauges, pressure relief valves, others

Items	Description
smoothness, gap/spaces, accuracy, setting value, condition of structures, others)	- Check all Electrical equipment, others - Check all Pipeline including valves, gates, others - Check all Instrumentation and Control equipment, others - Check all accrual condition after troubleshooting, others - Performance tests of all pumps, blowers, centrifuge and other equipment
3) Verification of rectified works (System, leakage, crack, damage, soil settlement, corrosion, others)	- Check a list of all defect items, history, tendency, repeating, others - Check a list of all miss operation and maintenance items, others - Check all factors of defect / near miss operation, others - Verification of action on the measures taken, and others - Verification of all rectified works with the reports and photo, others - Check emergency works and its factor, action plan, others - Check actual condition after rectified works, others
4) Operation skill (Staff member, others)	- Review of summary reports on O&M activities - Check time and activity of staff member, and others - Interview operator regarding troubleshooting, others - Paper test (basic knowledge, calculation of chemical dosing, safety, others) - Field test (using/put on the safety gear, drill of chlorine leakage accident, others)

5) Waste Water analysis
(Sampling and analysis, others)
	- Location of sampling and time, and date
	- Raw sewage and treated sewage
	  - Each unit process
	  - Authorized certificate from approved agency (or Bureau of Indian Standards Certified Laboratory)

6) O & M Record	- Check inventory list (parts, chemical, reagent, others) - Check the quantity of inventory, others - Check maintenance tools and equipment, vehicle, others
7) Spare parts and others	- Check inventory list (parts, chemical, reagent, others)

Items	Description
	- Check the quantity of inventory, others - Check maintenance tools and equipment, vehicle, others

5. Submission of the report on completion of O&M Contract:

The Contractor shall submit the completion report after passing the final tests.

The report shall consist of relevant documents, for request for issue the Completion certificate of 10 years O&M period, which is given below in Table 17. 2 but not limited to this.

Table 17. 2: Documents to be handed over at the End of 10 Years O&M Period

Contents	Description
1) Outline	- Summary of project, scope of work, location of project, main component with specification, others
2) Completion Photographs (At acceptance complete inspection, completion inspection and final inspection)	Photographs with short description - Civil (structural, buildings, others) - Mechanical, Electrical and I&C (equipment, facility, others) - Piping works
3) Inspection summary (At acceptance complete inspection, completion inspection and final inspection)	Appearance test /Visual/ Performance examination - Table of Summary of test activity based on daily and monthly - List of type of test, date, inspector, evaluation, comments - Civil (name of structure, drawing no., drawings, design dimension, previous dimension, actual dimension, others) - Mechanical (name of facility and equipment, tag no., quantity, others) - Electrical (name of facility and equipment, tag no., quantity, others) - Instrumentation and Control (name of facility and equipment, tag no., quantity, others)
4) Main inspection data (At construction)	Summary of data with graphic /chart - Civil (plate load bearing test, compressive strength test, water retaining test, compaction field test, road construction works in WwTP, hydrostatic test, others) - Mechanical test, others - Electrical (earthing resistance test, others) - Instrumentation and Control
5) Inspection record (At acceptance complete inspection, completion inspection and final inspection)	Appearance test /Visual/ Performance examination/ Verification of rectified works - Civil (Refer to Table 17.1, point no.1,2,3) - Mechanical (Refer to Table17.1, point no.1,2,3) - Electrical (Refer to Table 17.1, point no.1,2,3) - Instrumentation and Control (Refer to Table 17.1, point no.1,2,3)

Contents	Description
6) Training and commissioning record (At first and second training program)	- Summary (Schedule of training and commissioning, attendance rate, impression on training program) - Training attendance list (participants, trainings date, others) - Commissioning daily record (Sewage flow rate of designed and actual, name of operated facility, list of measurement and its time and reading value, raw sewage and treated sewage quality, value of V/A/kW of each equipment, others) - Photographs with short description
7) Sewage quality certification data (At acceptance complete inspection, completion inspection and final inspection)	- Location of sampling and time, and date - Raw sewage and treated sewage - All Process Units - Issued from Authorized entity
8) Operation and Maintenance manual (Civil, Mechanical, Electrical and Instrumentation &Control)	- Updated O&M Manual
9) O & M records	- Water quality analysis and consumption of electricity and chemicals - Screening, grit and sludge handling amount - List of O&M record, Ledger and operation record - Various types of Ledgers and other plant organization charts and plant management record including cost and expenditure - History of trouble shooting - O&M record of a process, unit operation and equipment - Mechanical (name of parts, tag no., quantity, location of stock, others) - Electrical (name of parts, tag no., quantity, location of stock, others) - Pipes & fittings (name of parts, tag no., quantity, location of stock, others) - Valve & Gates (name of parts, tag no., quantity, location of stock, others) - Instrumentation & Control (name of parts, tag no., quantity, location of stock, others) - Others (name of parts, tag no., quantity, location of stock, others)
10) Spare parts list	- Mechanical (name of parts, tag no., quantity, location of stock, others) - Electrical (name of parts, tag no., quantity, location of stock, others)

Contents	Description
	- Pipes & fittings (name of parts, tag no., quantity, location of stock, others) - Valve & Gates (name of parts, tag no., quantity, location of stock, others) - Instrumentation & Control (name of parts, tag no., quantity, location of stock, others) - Safety equipment and devices including for staff and for testing - Others (name of parts, tag no., quantity, location of stock, others)
11) Key list with boxes	- Name of key, location, tag no., quantity, Civil (all related material: reinforcement bar, cement, aggregate, sand, gravel, asphalt, crashed stone, chemical admixture, water reducing agent, pozzolana, water-tightness sheet, construction equipment, manhole, water-resistant coating, paint, windows, door, others) - Mechanical (all related equipment. screens, pumps, blowers, dewatering Centrifuge, Chlorine scrubbers, Chlorinators, scarper, conveyor, hopper, central drive & rotating mechanisms, pipes, valves, gates, pressure gauges, safety valves, safety equipment, flow meters, coating, painting, others) - Electrical (all related equipment: electrical wire, electrical conduit, motor, control panel, relay, transformer, heater, generator and silencer, timer, breaker, light/lamp, switch, street light, earthing, measurement equipment, air condition, communication equipment, electric pole, coating painting, ventilation fan, air duct, others) - Instrumentation & Control (all related equipment, others) - Safety equipment - Others
12) Manufacture produced catalogue (Civil, Mechanical, Electrical and Instrumentation &Control)	See above (11)
13) Instruction manual (Civil, Mechanical, Electrical and Instrumentation &Control)	See above (11)
14) Factory inspection record or Quality assurance (Civil, Mechanical, Electrical and Instrumentation & Control)	See above (11)

Contents	Description
15) Photograph (During Construction, at defect liability, at joint completion inspection) (Civil, Mechanical, Electrical, Instrumentation &Control)	History of Construction, Replacement of defect liability - Civil: Construction site before starting construction, earthwork, arrangement of bar, cleaning before placing, formwork, concrete mixing work, placing, vibrating, curing, remove of formwork, backfill, compaction, all field inspection and lab test, others - Mechanical: Inspection at factory, receiving inspection, completion inspection, all field inspection and lab. test, others - Electrical: inspection at factory, receiving inspection, completion inspection, all field inspection and lab. test, others - Instrumentation and Control: inspection at factory, receiving inspection, completion inspection, all field inspection and lab. test, others
16) Production samples (Civil, Mechanical, and Instrumentation &Control)	All samples for technical approval - Attach Analytical instruments name, approved sign of the Engineer.
17) Report	- Monthly and Annual report - Others
Note: *These data shall be provided both in soft and hard copies, in proper professional format.*	

17.3 Specifications

The specification of materials used for repairs shall be the same as have been used in the original work. Specifications for any materials which were not used during construction shall be approved by the Engineer prior to Handing Over.

17.4 Check List for ISPS, TSPS and WwTPs

17.4.1 General

Within the framework of the Contractor's responsibilities given above, the Contractor shall carry out the following activities. However, these shall not limit the requirement for other activities which otherwise are required as per terms and conditions of the Contract or to fulfill the Contractor's responsibilities or are essential as per good industrial practices. The Contractor shall hand over all the components of works in good working condition for the following, but not limited to:

a) All pumps, motors and other mechanical equipment etc., at the sewage treatment plant and Intermediate/Terminal Sewage Pumping Stations (all works constructed in this Contract).

b) All required consumables required for functioning of plant with inventory of material.

c) All Electrical Equipment's such as Transformers, 11kV Metal Enclosed Switchboards & Switchgears , 415 V metal enclosed switchgears (PCC) /MCC, 415 V Power capacitor and control panel, Diesel Standby Generator with AMF Control Panel and Synchronizing panel, Battery, battery charger and DC Distribution Board, Variable Frequency Drives, Non Segregated Bus Duct, Power & control cables, Cable carrier system, Lighting system, Earthing and lightning protection systems of the Plant (All works constructed in this Contract).

d) All Instrumentation and control equipment etc., (All works constructed in this Contract).

e) Administrative buildings etc. (All works constructed in this Contract) in neat and clean condition.

f) AMC contracts with system / equipment suppliers, as necessary for PLC and SCADA system supplier or the authorized system integrate or as executed the work for this project.

g) Lighting fixtures and the lighting system of all areas and replacement of all non-functional lighting fixtures.

h) Records for the followings but not limited to:
   - Water quality report
   - Repair history of all mechanical, electrical and instrumentation control equipment in sewage treatment plant and Intermediate/Terminal Sewage Pumping Stations, and communication instruments.
   - Logbooks through PLC/SCADA system.
   - Daily log of operations of all the important equipment with time tag.
   - Hourly readings of water levels, pressure sensors, flow rates and integrated quantity of water.
   - Operational cost.
   - Monthly Running hours of all the mechanical equipment and total electrical power consumption. (Power consumption by each Pump and each Pump House each blower and blower house)
   - Generator running hour and its production of electricity
   - Sludge, screenings and grit handling amount
   - Daily list of alarms with time tag.
   - Logbook format and the data to be included in the logbook.
   - Last periodic maintenance done for all equipment/buildings of the system.

i) Required spares, general and special tools & tackles, test equipment and adequate inventory of required accessories or equipment itself for repair/replacement of defective electrical, mechanical, instrumentation and control system, pipe, and the communication system. However, at the end of the Contract, the Contractor shall hand over the full spares, tools and tackles as supplied with the Contract by replacing the used items with fresh supplies of the same specifications.

j) Repair of the roads, buildings and campus area utilities.

k) Potable water supply facilities at treatment plant and sewage pumping stations and all its units.

l) Record of stores for the electrical, mechanical and instrumentation and control equipment as well as that for consumables. The records will include but shall not be limited to:
   - Materials received and issued for works.
   - Proper arrangement of material in stores to ensure its safety and easy availability.
   - Maintaining store areas in a neat and tidy condition.
   - Keeping records and accounting for the incoming materials,
   - Keeping records and accounting for the consumed materials.

m) Structures/buildings of campus areas of Wastewater Treatment Plant and Intermediate/Terminal Sewage Pumping Stations and others built in the Contract must ensure adequate cleanliness, ventilation, illumination and structural safety. In addition to this, the general hygienic standards must be in acceptable condition and adequate plantation horticultural activities must be well maintained to give pleasant environment of the campus / building.

n) Updated operation and maintenance manual as defined in specifications for O&M works.

o) 6 sets of Hard Copies and 2 sets of Soft copies of all “As Commissioned Final Drawings”.

17.4.2 Intermediate/Terminal Sewage Pumping Stations

The Contractor shall hand over all components of the works in good working condition for the following, but not limited to:

- All facilities from inlet gate/valve, to pumps, motors, valves, cranes, flow meters, blowers, screens, conveyors, PLC control,Transformers,11kV Metal Enclosed Switchboards & Switchgears, 415 V metal enclosed switchgears (PCC) /MCC, 415 V Power capacitor and control panel, Battery, battery charger and DC Distribution Board, Variable Frequency Drives, Non Segregated Bus Duct, Power & control cables, Cable carrier system, Lighting system, Earthing and lightning protection systems of the Sewage Pumping Station (All works constructed in this Contract).
- PLC, including the hardware, software and all instruments, in good working condition**.**
- Entire control system and instruments as per the contract and manufacturer's recommendations.
- Replacement of damaged controls, communication cables and power supply cables.
- Repair or replacement, as required, of all instruments such as flow meters, pressure transmitters, pressure gauges, level sensors/transmitters, float type level switches along with all other equipment.
- Calibration of all measuring/metering equipment or as recommended by the manufacturer. The calibration at manufacturer's works shall be done in case of major failure/ repairs of the instruments.
- Submission of daily and monthly customized reports produced by the local SCADA system.
- To provide all required consumables for a period of –12 months.
- Repair of damaged moving parts, steel structures, and the RCC structure. Subsequently the repairs, cleaning disinfection and painting of all civil works must have been done.
- Lubrication of all gears, motors, motorized valves, gates and other parts of the system.
- Check all valves and gates for their manual and electric operation. Operation of valves must be checked from local control console, switchgear and through PLC system. Any defect observed must be made good.
- Make good all circuits and buildings, all electrical, mechanical and instrumentation equipment, substation equipment, lighting, DG Set and earthing system associated including replacement, if any(as required).
- Painting of the exposed mild steel components of pipeline, ladders, railings etc. must be done.
- Make good landscaping of the surrounding areas of the pumping stations, free from shrubs, weeds, grass and other unwanted vegetation.
- Ensure safety accessories, e.g. gloves, shoes, first aid box, etc.
- Ensuring fire and safety equipment.

17.4.3 Lubrication

The Contractor, in the operation and maintenance manuals, shall furnish a complete schedule of recommended oils, grease, and other required lubricants.

The Contractor shall indicate the brand name of indigenously available equivalent lubricants, with their complete duty specifications, in the O&M manual. The Contractor shall also furnish the schedule of quantities for each fill, frequency of filling and annual requirement in O&M manual.

Where lubrication is affected by means of grease, preference shall be given to a pressure system which does not require frequent adjustment or recharging. Frequent, for this purpose, means more than once in a month. Where more than one type of special grease is required, a grease gun for each special type shall be provided for the usage.

17.4.4 Spare Parts

All spare parts used for the equipment in the maintenance of the system must be from the manufacturer of the equipment or, if the equipment itself has been made with parts from other manufacturers, the parts must be of the same make as used in the equipment supplied and installed.

All spare parts shall be packed for long storage under the climatic conditions prevailing at the Site. Each spare part shall be labeled on the outside of its packing with its description, number and purpose and, if more than one spare is packed in a single case, a general description of the case contents shall be shown on the outside and a packing list enclosed.

17.4.5 Electrical System

The Contractor shall hand over the following at the end of Operation and Maintenance Period:

- Revised as built drawings based on all modifications during O&M Period. All Electrical Drawings like Single Line Diagrams, Control Circuits Equipment Layout, Cable Layout, and Cable Schedules, Lighting Layouts, Earthing Layouts etc., should be maintained and handed over.
- Details of Protective Relay Settings and time relay settings including any changes done during the Operation and Maintenance period, Details of Oil Changes / Filtration of Transformers, Records of any changes made in the System during the Operation and Maintenance period etc. should be maintained.
- Equipment wise maintenance record during O&M Period, as per daily checking out / inspection and regular (every 6 months or 12 months).
- Motor wise Power consumption Details and overall power consumption detail of plant.
- Details of IR Test of all Equipment's like, HT / LT Switchgear Panels, Diesel Generators, Transformers and Cables etc. should be maintained.
- Log book showing details of Electrical faults that have occurred in the plant and record of corrective actions taken during O&M period.
- Equipment wise technical data given by equipment supplier, Documents showing Bill of Materials and Operation & Maintenance Manual (hard copy or soft copy).
- List of mandatory spares that are to be maintained at stores and their actual availability in plant, if it is below same has to be replenished.
- Details of Measurement of Earth resistance, Earth pit wise and overall values during the O&M Period.
- Details of Illumination Levels during the O&M Period along with details of changes, if any effected during the O&M period.

17.4.6 Electrical Checks to be done during handover after O&M Period

- Contractor to provide a test schedule & format to be approved by engineer before commencing any test.
- Checking of all electrical equipment, items etc. as per bill of materials. Visual checking and tracing out the circuit based on revised as built drawings.
- Physical Operational checks of all equipment & protections have to be done.
- Power frequency voltage tests & IR measurement for various electrical equipment, items & cables to be done.
- Testing of transformer oil samples.
- Measurement of earth resistance for individual earthing system & overall for the installation.
- Checking of Lightning Protection System.

- Measurement of illumination level at various premises.
- If any item is found to be faulty during the above checks/tests the same shall be rectified/replaced as necessary.

17.4.7 Instrumentation, Control and Automation System

The Contractor shall hand over the following documents/manuals/programs at the end of Operation and Maintenance Period for WwTP &ISPS/TSPSs under this contract:

- Detailed drawings and O&M manuals of all the Instruments, Panels, Valve Actuators, Field Instruments etc. supplied under the contract.
- Detailed drawing and manual of the PLC installed. Manual shall include the PLC series installed along with complete details on I/O modules, Ethernet switch, Relay modules, and converters (if any).
- A complete manual shall be provided which shall include operating instructions and troubleshooting techniques of the PLC and accessories installed illustrated with examples. This shall be provided along with the standard manufacturer's literature.
- A complete manual shall be provided which shall include operating instructions and troubleshooting techniques of the SCADA and accessories installed, illustrated with examples. This shall be provided along with the standard manufacturer's literature.
- A complete manual shall be provided which shall include operating instructions and troubleshooting techniques of the interface control panel to Cauvery Bhavan, illustrated with examples. This shall be provided along with the standard manufacturer's literature.
- Interoperability testing tool/software shall be provided along with relevant manuals and operating instruction with examples.
- Latest PLC program back-up, SCADA software back-up with license, SCADA database backup, reports and alarm back-up, Historical archived data containing reports and alarms and configuration set-up shall be provided.
- All software's used under ICA shall be handed over along with their original licenses.
- Complete list of database /addresses shall be provided clearly indicating the spare tags for PLC, SCADA software.
- List of mandatory spares that are to be maintained at stores for complete ICA package and their actual availability in plant, has to be provided.
- Any password's set to access the internal PLC program. interface control panel shall be provided and demonstrated.
- All passwords (PLC, Interface control panel & SCADA and other software/hardware) shall be provided in a sealed envelope.
- PLC, SCADA package shall be updated with the latest software version/ patch before handing over. The same has to be demonstrated to the engineer.
- Latest licensed version of windows operating system along with MS–Office or equivalent software which is prevailing at that point of time shall be installed on SCADA machines and other machines installed and integrated with the SCADA package. The same shall be demonstrated to the engineer.
- Contractor shall conduct an adequate training session for the client's staff which shall include PLC configuration, troubleshooting techniques, SCADA configuration and troubleshooting techniques, diagnostic techniques and troubleshooting techniques for wireless technology employed for communication.
- The training session shall be of duration of minimum Five (5) working days at a stretch.

- Manufacturer's literature/Manuals for flow meters, level transmitters, switches, pressure transmitters etc. and analytical instruments installed.
- Instrument wise, PLC and SCADA wise maintenance records of complete O&M period shall be provided.
- A complete and updated list of all manufacturers/system integrators/Contractors of ICA with contact numbers shall be provided. The same shall also be made available on site for ready reference.
- The final as commissioned versions of all drawings of ICA, which will include cable termination details, I/O mapping, database details etc. shall be provided in PDF format and editable format and loaded in the operator machine available on site. The same shall be demonstrated to the engineer.

17.4.8 ICA Checks to be done during handover after O&M Period for WwTP and ISPSs/TSPSs under this contract

- Contractor to provide a test schedule and format to be approved by the engineer before commencing any of the tests.
- Functional Checking of all Laboratory instruments, real time multi parameter influent and effluent monitoring systems, Auto samplers, and ICA equipment including PLC based SCADA system, flow meters, pressure and level instruments, vibration monitoring instruments, and wireless equipment being used for communication.
- Loop checks shall be conducted.
- All instrument cabling shall be inspected for continuity. If found faulty, the same shall be replaced and demonstrated.
- All instrumentation cable conduits shall be checked for damage. If found faulty, they should be rectified or replaced and sealed to the satisfaction of the engineer.
- Visual operational checks of all the Panels including PLC panel, SCADA system, and interface control panel, and Surge Control Panel.
- Licensing feature of PLC, SCADA software and hardware shall be demonstrated.
- Functional check of set points change at HMI/SCADA and its downloading to PLC's concerned.
- Hot-standby feature of PLC and hot swappable feature of I/O modules shall be demonstrated. If found to be faulty/non-operational, shall be rectified and if required replaced to normal working condition and demonstrated to the client.
- Dual-redundant server feature of SCADA shall be demonstrated. If found to be faulty/non-operational, shall be rectified and if required replaced to normal working condition and demonstrated to the client.
- Functional check of data received/transmitted from remote stations shall be conducted in conjunction with SCADA.
- Functional check of interface control panel to Cauvery Bhavan in conjunction with Master SCADA center at CP-24 & MIS-2 Shimsha Bhavan shall be conducted.
- Historical archiving of all data shall be demonstrated.
- Availability of memory for smooth operation of PLC, SCADA machines shall be demonstrated. If found to be in-adequate, the same shall be rectified /archived and demonstrated.
- If any instruments and automation equipment are found to be faulty during the above tests, the same shall be rectified or replaced as necessary.

17.4.9 Wastewater Treatment Plant and Terminal Sewage Pumping Station's Ancillary Works

- Make gardens and plantation in the campus area green, neat and tidy with removal of shrubs, weeds, grass and unwanted vegetation and make pruning, trimming and cutting from the Plant Area along with.
- Reinstate the roads and lighting fixtures and lighting circuits to and within the sites to original state.
- Make good and in working condition for lighting fixtures and lighting circuits, water supply facilities in Treatment plant, Sewage Pumping Stations, offices and other buildings.
- The Contractor shall carry out ordinary repairs to buildings, and other civil and ancillary works. The repairs may include but shall not be limited to the following items:
  - Easing of doors and windows, monsoon repairs to roofs, attention to drains, rain water spouts, attention to plinth protection.
  - External white or color wash, external and internal painting shall be carried out to all buildings irrespective of the condition and after any repairs including plastering, internal distempering,
  - All signs including those for access, warning signs (for example for hazardous, deep area, etc.) shall be in a condition equivalent to that at issue of the Commissioning Certificate.
  - The approach/access to and internal roads within the sites shall be in a condition equivalent to that at issue of the Commissioning Certificate. This shall include but not be limited to road surface (condition, camber, etc.), sub-surface, drainage, lighting (including power supply), and signage and road markings, pedestrian and animal access. Any safety and access issues which have been identified during the Operation Service period shall be addressed.
- Any faults in the electric installation, leakages, earthing, exposed wire ends and any hazards on this account to the users/inmates of the buildings, should be taken care of suitably, wiring, which is damaged or outlived, should be replaced.
- Damaged sanitary lines should be replaced and choked lines cleared.
- Proper drainage of the area around the building should be ensured to avoid stagnation of rain water/ house effluent, in order to prevent malarial conditions. Where courtyards exist in the buildings, their drainage into the outer drains should be ensured. Any choked drains should be cleared properly.
- Leaking roofs should be attended to immediately with suitable repairs/ treatment, as the case may be. The rain waterspouts should also be cleared of blockages, etc. The roof should be swept clean of leaves, debris, etc., if any.
- The plaster on outer walls of the building, which is exposed to weather, should be repaired before rains in order to prevent dampness inside. Where plinth protection has been provided, it should be checked and the damaged portions, if any, should be repaired before rains.
- Damaged / corroded / unsafe flooring should be repaired / replaced in order to (i) facilitate safe access, (ii) allow Plant to be removed to the flooring where required, (iii) prevent dampness inside the rooms, etc. during rains, etc. The same applies to hand railing.
- Repairs of damaged floors, door / window fittings, water taps, water coolers, furniture, desert coolers, electric circuits, must be taken up on complaints using the material of same quality as used during construction.
- Pump House, blower room ventilation system to be checked for effective heat dissipation from the Pump Motors and Electrical Equipment's.

17.4.10 Wireless Communication System

- Make good a wireless communication system to ensure reliable and easy communication to and from WwTP and ISPS/TSPSs under this contract. Make good a wireless communication system to

ensure reliable and easy communication to and from WwTP and Master SCADA control center at Shimsha Bhavan.

- Replacement of batteries, faulty sets and all other non-functional equipment to ensure trouble free communication if required.

17.5 Completion Documents for ISPS, TSPS and WwTPs

Completion (Handing over) documents shall include on a minimum five (5) sets of softcopies and five (5) sets of hard copies. The hard copies shall be provided with hard bind clearly indicating the version/revision submitted. All the contents shall be indexed. The contents of completion documents shall be clearly legible and shall include original manufacturer's literature on a minimum and incorporate any changes as per site conditions.

The comprehensive updated operation and maintenance manuals six (6) sets shall be submitted at the end of the operation and maintenance period. It shall be updated based on the principals broadly listed in Part-16.

17.6 As-Built Drawings for ISPS, TSPS and WwTPs

Revised As-built drawings based on all modifications during O&M Period shall be submitted at the end of O&M period. It shall include all drawings of treatment units (plan and all necessary sections), utility and ancillary buildings, site layout of treatment plant and pumping stations, drawing of pump house, layout of pumps and all other mechanical equipment and piping, all electrical drawings like Single Line Diagrams, Schematic Diagrams, Control Circuits Equipment Layout, Cable Layout & Cable Schedules, Earthing Layouts and all ICA Drawings like P&ID, System configuration diagram (PLC & SCADA architecture), Instrument installation drawings, Instrument cable schedule, and cable layouts. Six (6) sets of the revised as-built drawings shall be submitted in hardcopies and softcopies (editable form).

17.7 Prices for Handover

The Contractor, at the time of bidding, will be responsible to ensure the completeness and adequacy of his Bid Price to fulfill the entire responsibilities as described above. His bid price, as quoted on a yearly basis in the Schedule of Prices, shall include all costs for handing over.

17.8 Completion certificate for O&M Contract

- The Contractor on completion of O&M period will request the Employer for a joint inspection of the Plant, after ensuring that all the Plant equipment's are in good handing over condition and all the requirements / documents as specified in this contract are also ready for handing over.
- Based on above request a Joint Inspection with Engineer shall be arranged by the Contractor to assess the condition of civil structure, mechanical, electrical and instrumentation equipment and First Joint Inspection Report, for various required remedial actions, repair actions, replacement actions, tests etc. shall be prepared.
- The Contractor shall attend to all points of Joint Inspection Report, by carrying out all such remedial / repair / replacement actions, tests at his own cost, and after attending, will confirm the same to the Employer.
- On receipt of the confirmation as above, Second Joint Inspection shall be arranged by the Contractor, for certification of completeness of remedial work, as well as condition of all civil works to its original appearance.
- The Contractor shall submit the entire required documents to Employer for review and comments. The Contractor shall resubmit the documents incorporating the comments.

- The Employer shall issue the Completion Certificate of the O&M Contract to the Contractor within 30 days of acceptance of Second Joint Inspection Report, subject to the above documents and obligation are met by the Contractor before 90 days prior to handing over of the plant.

End of Part 17

PART 18

ENVIRONMENTAL MANAGEMENT PLAN (EMP)

AND

ENVIRONMENTAL MONITORING PLAN (EMoP)

CONTENTS

PART 18

ENVIRONMENTAL MANAGEMENT PLAN (EMP)

AND

ENVIRONMENTAL MONITORING PLAN (EMoP)

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PART -18
ENVIRONMENTAL MANAGEMENT PLAN (EMP)
AND
ENVIRONMENTAL MONITORING PLAN (EMoP)

18.1 General

Mitigation measures and monitoring for Environmental and Social considerations shall be carried out by the Contactor during the Construction and Operation Service Phases in accordance with the Environmental Management Plan (EMP) and the Environmental Monitoring Plan (EMoP). The results of monitoring will be provided to World Bank on a quarterly basis during the Construction Phase and biannually during the Operation Service Phase till the end of the Project. In case the results of monitoring contravene Indian and/or International Standards and/or tender requirements and/or significant adverse impact(s) is/are identified, necessary measures shall be taken by the Contractor with no additional cost.

18.2 Proposed Environmental Management Plan (EMP)

The Contractor shall carryout mitigation measures based on the proposed Environmental Management Plan (EMP) including indemnification as indicated below.

18.2.1 Construction Phase - EMP

S. No	Impacts	Proposed Mitigation Measures	Actor for Mitigation Measures	Regulatory Authority
1	Social Infrastructure / Service	• Prior notice to traffic police before the construction works. • Placement of traffic guides at each end of construction sections for smooth inducement of traffic. • Careful examination of Contractor's construction plan and schedule. • Setting detouring route if necessary. • Sufficient information disclosure such as construction period or work section to media such as television, radio, newspapers, etc. as well as utilization of internet media. • Socialization activity to local residents including distribution of leaflet or announcement letters or holding meetings if required. • Implementation of underground utility survey for existing water pipes, power lines, telephone lines and gas pipes not to cause damage on these utilities. • Adoption of trenchless method at crossing points of roads with heavy traffic and	Contractor	Police/ BWSSB/ Consultant

S. No	Impacts	Proposed Mitigation Measures	Actor for Mitigation Measures	Regulatory Authority
		railway crossings.		
2	Infectious Diseases	• Preparation of appropriate working health plan. • Training of working health for workers. • Biannual health camps for workers	Contractor	NACO/ KSAPS/ BWSSB/ Consultant
3	Occupational Health and Safety including communication plan	• Preparation of construction plan. • Training of construction workers. • Formulation of procedure to work in confined space. • Preparation of emergency safety plan. • Provide construction workers with sufficient personal. • Provide safety action items for fall / trips / electrical shocks / highest / scaffolding etc., • Protective equipment such as hard hats, earpiece, safety shoes, goggles, and others. • Emergency safety equipments such as Breathing apparatus, reviving apparatus, Vessels containing oxygen or air, Safety harness & ropes and Audio alarms for alerting workers at construction site. • Conduct explanation meetings on safety issues for local communities. • Install warning signs whereas the potential dangers are expected. • Erect temporary fence around high-risk areas to control public access and light them at night if that is on the regular roads used by the locals. • Assign construction staffs on or near places where construction vehicles are crowded to ensure safety.	Contractor	KSPCB/ BWSSB/ Consultant
4	Air Pollution	• Preparation of construction plan for control dust and particulate matter. • Examination of Contractor's construction plan especially on dust control and particulate matter. • Monitoring of Contractor's dust and particulate matter control.	Contractor	KSPCB/ BWSSB/ Consultant
5	Waste	• Preparation of construction plan for excavated soil and demolition waste.	Contractor	KSPCB/

S. No	Impacts	Proposed Mitigation Measures	Actor for Mitigation Measures	Regulatory Authority
		• Examination of Contractor's construction plan. • Monitoring of Contractor's management of excavated soil, construction debris.		BWSSB/ Consultant
6	Noise / Vibration	• Utilization of low-noise type construction machineries. • Temporary enclosure of the site during the construction works if necessary. • Instructing the Contractors to examine low noise/vibration construction methods. • Encouragement of idling reduction to the workers. • To avoid works at night and early morning at the sites close to residential areas, schools and hospitals. • Monitoring of noise level at facility boundaries.	Contractor	KSPCB/ BWSSB/ Consultant
7	Accident	• Preparation of appropriate construction vehicle operation plan to avoid concentration of machinery and vehicles in limited roads. • Allotment of traffic guide for proper control of traffic in order to minimize disruption to traffic flows. • The construction site should be enclosed with temporary fence to provide a visual barrier between the construction site and adjacent traffic. • Contractor's advance notification to communities in case of blocking traffic for transport of heavy equipment.	Contractor	Police/ BWSSB/ Consultant

18.2.2 Operation Phase - EMP

S. No.	Impacts	Proposed Mitigation Measures	Actor for Mitigation Measures	Regulatory authority
1	Occupational Health and Safety including communication plan	• Facility design for prevention of leakage of chlorine gas in design. • Containment bunds for all chemical storage area and tanks. • Preparation of plant O&M plan. • Training of O&M workers.	Contractor	KSPCB / BWSSB / Consultant

S. No.	Impacts	Proposed Mitigation Measures	Actor for Mitigation Measures	Regulatory authority
		• Formulation of procedure to work in confined space. • Monitoring of O2, H2S and CH4 for confined space work. • Preparation of emergency safety plan. • Preparation of emergency action plan. • Protection equipment such as hard hats, earmuffs, safety shoes, and others. • Emergency safety equipments such as Breathing apparatus, reviving apparatus, Vessels containing oxygen or air, Safety harness & ropes and Audio alarms for alerting workers. • Install warning signs whereas the potential dangers are expected.		
2	Water Pollution	• Preparation of appropriate O &M manual for WwTPs. • Regular monitoring of water quality at WwTPs and its discharge water bodies.	Contractor	KSPCB / BWSSB / Consultant
3	Waste (Screen, Grit, Sludge, Effluent, Lubricant)	• Preparation of manifest system for treatment, transport and final disposal of waste. • Monitoring of manifest of generation, transport and final disposal of waste. • Agreement among relevant authorities such as BWSSB, Contractors and farmers for sludge as manure.	Contractor	KSPCB / BWSSB / Consultant
4	Soil Contamination	• Preparation of appropriate maintenance plan of the facilities for prevention of damage. • Early detection of occurrence of leakage of sewage at main sewers. • Visual and odor inspection as regular maintenance. • Quick response to the local residents' information relating to occurrence of odor and detection of leakage of sewage.	BWSSB	KSPCB / Consultant
5	Noise / Vibration	• Equipment layout/configuration plan at detail design. • Facility design on the materials with high sound absorption and insulation effects. • Monitoring of noise level at the facility boundaries of the WwTPs and ISPSs.	Contractor	KSPCB / BWSSB / Consultant

S. No.	Impacts	Proposed Mitigation Measures	Actor for Mitigation Measures	Regulatory authority
		• Installation of soundproof wall if necessary.		
6	Odour	• Facility design for reduction of odour generation. • Monitoring of odor level at the facilities and boundaries of the WwTPs and ISPSs sites. • Establishment of handling complaints of the residents and quick response to take measures.	Contractor	KSPCB / BWSSB / Consultant
7	Accident	• Safe operation of site. • Preparation of appropriate construction vehicle operation plan to avoid concentration of machinery and vehicles in limited roads. • List of emergency contacts including hospitals and first responders. • Allotment of traffic guide for proper control of traffic in order to minimize disruption to traffic flows. • Sites enclosed with permanent compound wall to protect facilities from site neighborhood. • Contractor's advance notification to communities in case of blocking traffic for transport of heavy equipment and other site wastes.	BWSSB/ Contractor	Police/ BWSSB/ Consultant
8	Climate Change	• Facility design of pump units and blower with high efficiency and inverter type. • Optimum operation of pump in accordance with process flow rate.	Contractor	KSPCB / BWSSB / Consultant
9	Infectious Diseases	• Preparation of appropriate working health plan. • Training of working health for workers. • Biannual health camps for workers	Contractor	NACO/ KSAPS/ BWSSB/ Consultant
10	Poverty	• Implementation of public awareness programme.	BWSSB	GoK

Abbreviations:

KSPCB Karnataka State Pollution Control Board

GoK Government of Karnataka

KSAPS Karnataka State Aids Prevention Society

NACO National Aids Control Organization

18.3 Proposed Environmental Monitoring Plan (EMoP)

The Contractor shall carry out the Environmental Monitoring Plan (EMoP) as indicated below.

18.3.1 Construction Phase - EMoP

No.	Item	Location	Parameters	Method	Frequency	Implementing Agency/Responsibility
1	Air Pollution	• Facility boundaries at construction sites.	• Dust. • Particulates.	• Air Quality Meter. • Examination of daily or monthly report.	Monthly	Contractor
2	Waste	• Construction sites for excavation works. • Construction sites for Backfill. • Final disposal site of construction debris.	• Type of construction debris. • Amount of construction debris. • Amount of excavated soil.	• Visual inspection. • Examination of daily or monthly report.	Monthly	Contractor
3	Noise / Vibration	• Facility boundaries at all ISPSs and WwTPs facilities. • All sewer network facilities.	• Noise level	• Measurement of noise level by decibel meter. • Examination of daily or monthly report.	Monthly	Contractor
4	Accident	• Construction sites.	• Safety measures. • Construction practice.	• Visual inspection. • Examination of daily or monthly report.	Monthly	Contractor

18.3.2 Operation Phase - EMoP

No.	Item	Location	Parameters	Method	Frequency	Implementing Agency/Responsibility
1	Water Quality	• At WwTPs facilities (Raw sewage,	• pH • BOD_5 • COD	• As per the methods of Indian standards.	Daily	Contractor

No.	Item	Location	Parameters	Method	Frequency	Implementing Agency/Responsibility
		Effluent)	• TSS • NH4-N • T-N • T-P • Fecal Coliforms			
2	Waste	• All ISPSs and WwTPs facilities as applicable. (Screen, Grit, Sludge, Effluent, Lubricant)	• Location of final disposal site. • Final disposed quantity.	• Examination of daily or monthly report.	Monthly	Contractor
3	Noise / Vibration	• Facility boundaries at all ISPSs and WwTPs facilities	• Noise level	• Measurement of noise level by decibel meter	Monthly	Contractor
4	Odour	• Facility boundaries at all ISPSs and WwTPs facilities	Odour level of the following chemical substances as odour source: • Ammonia • Methyl mercaptan • Hydrogen sulfide • Methyl sulfide • Styrene	• Japanese Offensive Odor Control Law (Law No. 91 of 1971, Latest Amendment by Law No. 71 of 1995) or • Prevailing Indian standard	Monthly	Contractor
5	Accident	• All WwTP sites and surrounding areas • All ISPS sites and surrounding areas.	• Operation and maintenance practice	• Visual inspection • Examination of daily or monthly report	Monthly	Contractor

18.4 Construction Phase - Environmental Monitoring Forms

18.4.1 Air Quality

Method	Proposed Location	Frequency	Measured Value			
Air Quality Meter	• At construction sites.	Monthly (Examination of daily or monthly report)	Item	Yes	No	Measures Taken (Refer Notes)
			Dust			
			Particulates			
			Vehicle Emissions			
			Other (Specify:)			

Notes:

1. *Sprinkling of surfaces, re-vegetation, and delayed stripping of vegetative cover where practical.*
2. *Water stockpiles and storage areas to prevent dust pollution.*
3. *Cover trucks transporting construction materials to minimize spills.*
4. *Shall not overload vehicles.*
5. *Tune and service regularly all construction and transportation vehicle / equipment in order to prevent air pollution.*

18.4.2 Waste

Method	Proposed Location	Frequency	Measured Value	
Visual inspection	• Construction sites for excavation works. • Construction sites for backfill. • Final disposal site of construction debris.	Monthly (Examination of daily or monthly report)	Item	Amount
			Type of construction debris.	
			Mount of construction debris.	
			Amount of excavated soil.	
			Location of final disposal sites of construction debris.	
			Location of final disposal sites of excavated soil.	

18.4.3 Noise / Vibration

Monitoring Item	Measured Value		Standards	Frequency	Measurement Point
	(Mean)	(Max.)			
Noise Level			Indian standard*	Monthly	Facility boundaries at construction sites.

** Indian standard as per Schedule III under the Noise Pollution (Regulation and Control) Rules, 2000 and amendment 2002*

Area Code	Category of Area	Limits in dB (A)	
		Day time	Night time
A	Industrial	75	70

Area Code	Category of Area	Limits in dB (A)	
		Day time	Night time
B	Commercial	65	55
C	Residential	55	45
D	Silence zone	50	40

Notes:

1) Daytime is reckoned in between 6:00 AM to 10:00 PM.

2) Night time is reckoned in between 10:00 PM. to 6:00 AM.

3) Silence zone is defined as areas up to 100 meters around such premises as hospitals, educational institutions, and courts. The silence zones are to be declared by the Competent Authority. Use of vehicular horns, loudspeakers and bursting of crackers shall be banned in these zones.

4) *Mixed categories of areas should be declared as one of the four above-mentioned categories by the Competent Authority and the corresponding standards shall apply.*

18.4.4 Accident

Item	Monitoring Place	Monitoring Method	Frequency	Monitoring Result
Adequate safety traffic control manners.	Construction sites	• Visual inspection. • Examination of daily / monthly report.	Monthly (Examination of daily or monthly report)	

18.5 Operation Phase - Environmental Monitoring Forms

18.5.1 Water Quality (Treated Effluent)

SI. No	Parameters	Measured Value		Standards*	Frequency	Measurement Point
		(Mean)	(Max.)			
1	pH			6.0 – 8.5	Daily	At all WwTPs facilities
2	BOD_5			< 10	Daily	
3	COD			< 50	Daily	
4	TSS			< 10	Daily	
5	T-N			< 10	Daily	
6	T-P			< 1	Daily	
7	Fecal Coliform**			< 100	Daily	
* In mg/L apart from No.7, **MPN/100 mL						

18.5.2 Waste

Monitoring Item	Proposed Location	Frequency	Location of final disposal site.	Final disposed quantity
Screen, Grit, Sludge, Effluent, Lubricant.	• At all WwTPs and ISPSs facilities as applicable. • Final disposal site.	Monthly (Examination of daily or monthly report)		

18.5.3 Noise / Vibration

Monitoring Item	Measured Value		Standards	Frequency	Measurement Point
	(Mean)	(Max.)			
Noise Level			Indian standard*	Monthly	At all WwTPs and ISPSs facilities
** Indian standard as per Schedule III under the Noise Pollution (Regulation and Control) Rules, 2000 and amendment 2002*					

18.5.4 Offensive Odor

Monitoring Item	Measured Value (Mean)	Measured Value (Max.)	Standards (ppm)	Measurement Point	Frequency
Ammonia			1.0	At all WwTPs and ISPSs facilities	Monthly
Methyl mercaptan			0.002		
Hydrogen Sulfide (H_2S)			0.02		
Methyl sulfide			0.01		
Styrene			0.4		

Notes:

1. *Japanese Offensive Odour Control Law, Law No. 91 / 1971 or latest amendment by Law No. 71 / 1995 or Prevailing Indian Standard.*

18.5.5 Air Quality

Monitoring Item	Proposed Location	Frequency	Measured Value			
• Air Quality	• At all WwTPs and ISPSs facilities.	Monthly (Examination of daily or monthly report)	Item	Yes	No	Measures Taken (Refer Notes)
			Dust			
			Particulates			
			Vehicle Emissions			

Notes:

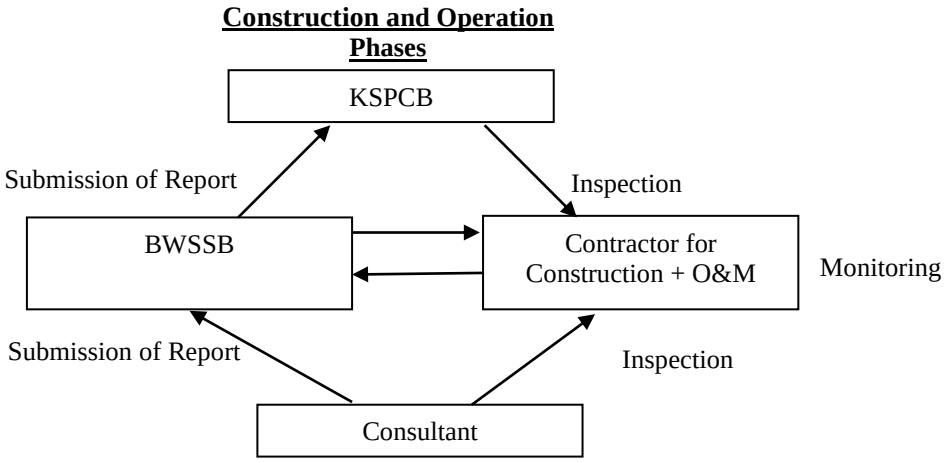
1. *Cover the trucks (or use Bulkers) for transporting waste material (Screen, Grit, Sludge) to minimize spills.*
2. *Shall not overload vehicles.*
3. *Tune and service regularly all transportation vehicles in order to prevent air pollution.*

18.5.6 Accident

Item	Monitoring Place	Monitoring Method	Frequency	Monitoring Result
Adequate safety traffic control manners Safe operation of site	• All WwTP sites and surrounding areas • All ISPS sites and surrounding areas	• Visual inspection • Examination of daily / monthly report	Monthly (Examination of daily or monthly report)	

18.6 Implementation Structure for Environmental Monitoring

The implementation structure for the environmental monitoring is shown in the following figure. The main actor of the environmental monitoring will be the Contractor who should undertake each project component of this Contract in the project phases of construction, operation and maintenance. The Consultant and BWSSB will inspect and supervise the Contractor's mitigation measures.



End of Part 18

Section 7A

Form of Technical Proposal

SECTION 7A: FORM OF TECHNICAL PROPOSAL

Name of the Contract: [*Insert as indicated in the tender*]

To:
Office of the Chief Engineer (Project),
Bangalore Water Supply and Sewerage Board
Cauvery Bhavan, 3rd floor,
K G Road, Bangalore 560 009,
Karnataka (India)

Sir,

We have examined the Conditions of Contract, Employer's requirements (Technical Specifications), Technical Schedules and Addenda Nos. _____ (*Insert nos.*), clarifications and the matters set out in the tender documents. We understood and checked these documents and not found any errors in them. We accordingly offer to design, construct, execute and complete and also operate and maintain the said Works and remedy any defects therein, in conformity with these documents and the enclosed Proposal. [*The following sentence is for Joint Ventures only*]. We hereby confirm that all partners of the joint venture are jointly and severally liable for execution of the Contract in accordance with the terms and conditions of the Contract.

We shall confirm all works, Plants, units, equipment including piping shall be designed as per the Technical specification in complete manner without any deviation.

We further undertake, if invited to do so by you, and at our own cost, to attend a clarification meeting at a place of your choice, for the purpose of reviewing our Technical Proposal and duly noting all amendments and additions thereto, and noting omissions there from that you may require, and to submit additional information that you require without any change to our price proposal as submitted with our tender or substance of the tender, in accordance with clause 22.1 of the ITT.

Yours faithfully

Signature _____in the capacity of _____duly authorized to sign bids for and on behalf of _____

Address: _____
_____
_____

Date: _____

NOTE: This form shall be filled and printed on the Company letter head, Signed, Scanned and uploaded. Failure to furnish the signed copy will lead to Non-Responsive Tender.

Section 7B

Technical Schedule

TECHNICAL SCHEDULE I

CONSTRUCTION PROGRAMME

The Tenderer shall submit a realistic construction programme which he proposes to adopt for executing the Works. This shall be in sufficient detail so as to show the order and duration of key activities required to carry out the Works (including each stage of mobilization of labour & equipments, setting up of site offices/ workshops/ consents and approvals, procurement, manufacture, pre-delivery inspection and testing, delivery to Site, construction, erection, testing and commissioning).

The Tenderer should pay particular attention to ensuring that the proposed programme is integrated with the Method Statement.

The construction programme shall be developed and presented on a commercially available project management software (such as Primavera, MS Project or equivalent), together with bar charts and CPM diagrams which clearly illustrate the critical path to achieve the desired results.

TECHNICAL SCHEDULE II

PROPOSED PLANT DETAILS
(To be completed by the Bidder)

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TECHNICAL SCHEDULE II

Name of the WwTPs	**Refer Volume 2 / Section 7**

Notes:

1) Bidder shall complete the TECHNICAL SCHEDULE II for WwTPs, TSPS.
2) Sizes of process and civil units shall mean Length x Width x Depth/Height as applicable and shall be expressed in "metres" unless specified otherwise.
3) Bidder shall furnish all the details in table and no part of the table is allowed to write "During Detailed Engineering".
4) Bidder shall write "NIL" wherever not applicable to the respective plant depending upon the process requirement as specified in Part 5.
5) All Equipment shall be of reputed make and shall qualify the criteria as mentioned in Part 8, General Mechanical Requirements of Tender document.
6) Original Vendor catalogue shall be included for Trash Screens, Coarse Screens, TSPS Pumps, Fine Screens, Vortex Grit Chamber, Submersible Mixers, Air Diffusers, Air Blowers, RAS Pumps, Decanter, Centrifuge Feed Pumps and Centrifuge.

2.1 Mechanical Works- WwTPs

2.1.1 Mechanical Fine Screen –Mesh/Punched hole Screen

S. No.	Description	Units	Particulars
(a)	**General**		
	(i) Make		
	(ii) Model		
	(iii) Quantity (W+S)	Nos.	
	(iv) Type		
(b)	**Screen**		
	(i) Mesh/Punched hole opening size	mm	
	(ii) Width	mm	
	(iii) Height	mm	
	(iv) speed	m/min	
	(v) Motor rating	kW	
	(vi) Water Level	m	
(c)	**Materials of Construction** (i) Frame		
	(ii) Brush & Jet nozzle system		

S. No.	Description	Units	Particulars
	(iii) Mesh/ Punched hole plate		
	(iv) Fasteners		
	(v) Canopy		
(d)	**Screw Conveyor System**		
	(i) Make		
	(ii) Material		
	(iii) Speed	rpm	
	(iv) Motor rating	kW	
	(v) Size of screw	mm	
	(vi) Angle of screw	Deg.	
(e)	**Unit Control Panel**		
	(i) Make		
	(ii) Over all dimensions	m x m x m	
	(iii) Degree of protection		
	(iv) Timer • Make • Type		

Note: - Bidder can quote for Combi unit for Inlet Headworks in place of (Fine screen + Vortex Grit mechanism)

2.1.2 Pre-Treatment Process (Combi Unit)

S. No.	Description	Units	Particulars
(a)	**General**		
	(i) Make		
	(ii) Model		
	(iii) Quantity (W+S)	Nos.	
	(iv) Type		
	(v) Capacity		
	(vi) Total length	m	
	(vii) Total width	m	
	(viii) Tank height	m	
	(ix) Total height	m	
	(x) Inlet		
	(xi) Outlet		
	(xii) Residue outlet		
	(xiii) Total weight empty	Kg	

S. No.	Description	Units	Particulars
	(xiv) Total weight under operation condition	Kg	
	(xv) Total weight completely flooded	Kg	
(b)	**Screen**		
	(i) Capacity		
	(ii) Diameter of screen basket	m	
	(iii) Perforated plate		
	(iv) Installation angle	Deg.	
	(v) Discharge height	m	
	(vi) Material		
(c)	**Drive motor**		
	(i) Make		
	(ii) Type		
	(iii) Nominal power	KW	
	(iv) Nominal current	Amp.	
	(v) Voltage	V	
	(vi) Frequency		
	(vii) Protection class		
	(viii) Insulation class		
	(ix) Efficiency classes		
(d)	**Automatic drum cleaning**		
	(i) Wash water demand		
	(ii) Required pressure	Bar	
	(iii) Water quality (Particle size)		
	(iv) Water connection		
(e)	**Solenoid valve**		
	(i) Make		
	(ii) Material		
	(iii) Quantity	Nos.	
(f)	**Grit trap type, aerated**		
	(i) Capacity		
	(ii) Separation degree		
	(iii) Particle size		
	(iv) Material		
(g)	**Drive motor (For horizontal grit screw and inclined grit screw)**		

S. No.	Description	Units	Particulars
	(i) Make		
	(ii) Type		
	(iii) Nominal power	KW	
	(iv) Nominal current	Amp	
	(v) Voltage	V	
	(vi) Frequency		
	(vii) Protection class		
	(viii) Insulation class		
	(ix) Efficiency classes		
(h)	**Rotary Lobe Blower/compressor**		
	(i) Suction capacity		
	(ii) Pressure	Bar	
	(iii) Pressure connection		
	(iv) Make		
	(v) Type		
	(vi) Nominal power	KW	
	(vii) Nominal current	Amp	
	(viii) Voltage	V	
	(ix) Frequency		
	(x) Protection class		
(i)	**Grease Trap**		
	(i) Material		
(j)	**Drive motor**		
	(i) Make		
	(ii) Type		
	(iii) Nominal power	KW	
	(iv) Nominal current	Amp	
	(v) Voltage	V	
	(vi) Frequency		
	(vii) Protection class		
	(viii) Insulation class		
	(ix) Power factor		
	(x) Efficiency classes		
	(xi) Weight	Kg	
(k)	**Overload Protection**		
	(i) Make		
	(ii) Type		
(l)	**Grease Pump**		
	(i) Medium to be transported		

S. No.	Description	Units	Particulars
	(ii) Make		
	(iii) Type of pump		
	(iv) Capacity		
	(v) Pressure	Bar	
	(vi) Nominal power	KW	
	(vii) Voltage	V	
	(viii) Frequency		
	(ix) Protection class		
	(x) Efficiency classes		
	(xi) Suction connection		
	(xii) Pressure connection		

2.1.3 Vortex Type Grit Removing Equipment

S. No.	Description	Units	Particulars
(a)	**General**		
	(i) Make		
	(ii) Model		
	(iii) Quantity (W+S)	Nos.	
	(iv) Type		
(b)	**Reduction Gear**		
	(i) Make		
	(ii) Type		
(c)	**Drive Motor**		
	(i) Make		
	(ii) Speed	rpm	
	(iii) Rating	kW	
(d)	**Materials of Construction**		
	(i) Paddle Agitator		
	(ii) Frame		
	(iii) Walkway		
(e)	**Screw Classifier Mechanism** (i) Make		
	(ii) Type		
	(iii) Peripheral velocity	m/sec	
	(iii) Size of the Equipment • Diameter • Height	 mm mm	

S. No.	Description	Units	Particulars
	(iv) Drive System • Make of reduction gear • Make of motor		
	(v) Material of Screw		
	(vi) Safety device		
	(vii) Width/diameter of conveyor	mm	
	(ix) Speed of Classifier	m/sec	
	(x) Motor rating	kW	
(g)	**Organic Vane Return Pump set** (i) Make &Type of • Pump • Motor		
	(ii) Motor rating	kW	
	(iii) Materials of Construction • Casing • Impeller • Shaft • Seal		
(h)	**Air Lift Pump**		
	(i) Make		
	(ii) Type		
	(iii) Rating	kW	
	(iv) Material of Construction - Casing - Impeller - Shaft		

2.1.4 Air Blower for Vortex Type/Diffused Grit Removing Equipment

S. No.	Description	Units	Particulars
(a)	**General**		
	(i) Make		
	(ii) Type		
	(iii) Quantity (W+S)	Nos.	
	(iv) Capacity at NTP	m^3/min	

S. No.	Description	Units	Particulars
	(v) Design maximum discharge pressure	mlc	
	(vi) Efficiency	%	
	(vii) Speed, blower	rpm	
	(viii) Absorbed power	kW	
	(ix) Motor rating	kW	
	(x) Speed, motor	rpm	
	(xi) Noise level at Duty Point in dB(A) at 1.86 m from the unit	dB(A)	
	(xii) Vibration	mm/sec	
	(xiii) With Acoustic Hood	dB(A)	
	(xiv) Without Acoustic Hood	dB(A)	
	(xv) Weight – Blower	kgs	
	(xvi) Maximum lifting weight	kgs	
	(xvii) Dimensions (L x W x H)	m x m x m	
	(xviii) Coupling Type		
	(xix) Coupling Make		
	(xx) Cooling System		
(b)	**Material of construction:**		
	(i) Casing		
	(ii) Impeller		
	(iii) Shaft		
	(iv) Common Base frame		
	(v) Orientation		
(c)	**Acoustic Hood:**		
	(i) Type		
	(ii) Material of Construction		
(d)	**Inlet/Outlet silencer**		
	(i) Type		
	(ii) Make		
	(iii) Filter media		
	(iv) Mean air velocity	m/s	
(e)	**Noise reduction (mean) Air release valves**		
	(i) Number	Nos.	
	(ii) Diameter	mm	
	(iii) Type		
	(iv) Set pressure	bar	
	(v) Make		
(f)	**Delivery non-return valves**		
	(i) Number	Nos.	
	(ii) Diameter	mm	
	(iii) Type		
	(iv) Make		

S. No.	Description	Units	Particulars
(g)	**Delivery isolation valves**		
	(i) Number	Nos.	
	(ii) Diameter	mm	
	(iii) Type		
	(iv) Make		

2.1.5 Clarifiers

S. No.	Description	Units	Particulars
(A)	**Primary Clarifiers**		
(a)	**General**		
	(i) Number		
	(ii) Flow per clarifier	cum/hr	
	(iii) Up flow rate	m/h	
	(iv) Length x Width	m x m	
	(v) Liquid depth each	m	
	(vi) Free board	m	
	(vii) Volume	cum	
(b)	**Scraping mechanism:**		
	(i) Make		
	(ii) Type		
	(iii) Size (Diameter x SWD x FB)	m	
	(iv) Scraper speed	rpm	
	(v) Peripheral velocity	m/sec	
	(vi) Design Torque	N-m	
	(vii) Weir plate size (Thick x width)	mm	
	(viii) Safety device		
(c)	**Plate Settler**		
	(i) Make		
	(ii) Type		
	(iii) Size/Cross-Sectional Area	mm x mm	
	(iv) Number of plate per clarifier	Nos.	
	(v) MOC		
	(vi) UV Protection		Yes/No
	(vii) Length of the plate	m	
	(viii) Degree of Inclination	degree	
	(ix) MOC of Supporting Structure		
(c)	**Speed reduction drive**		
	(i) Make		
	(ii) Type		
	(iii) Speed reduction ratio		
	(iv) Torque		
	(v) Lubrication type		

S. No.	Description	Units	Particulars
(d)	**Surface preparation & Protection:**		
	(i) Wetted parts		
	(ii) Exposed parts		
(e)	**Material of construction:**		
	(i) Bridge and Superstructure		
	(ii) Feed well		
	(iii) Walkway Chequered Plates		
	(iv) Squeegees		
	(v) Weir plate		
	(vi) Clamps & Hardware		
(f)	**Motor:**		
	(i) Motor rating	kW	
	(ii) Motor speed	rpm	
	(iii) Motor Make		
	(iv) Protection		

2.1.6 Primary Sludge Pump set

S. No.	Description	Units	Particulars
(a)	**General**		
	(i) Make		
	(ii) Model		
	(iii) Type		
	(iv) Quantity (W+S)	Nos.	
(b)	**Performance**		
	(i) Capacity	cum/hr	
	(ii) Total head	mlc	
	(iii) Speed	rpm	
	(iv) Overall efficiency (Pump + Motor)	%	
	(v) Motor Rating	kW	
(c)	**Materials of Construction**		
	(i) Casing		
	(ii) Rotor		
	(iii) Stator		
	(iv) Line Shaft		
	(v) Mechanical Seal		
	(vi) Base Plate		
	(vii) Delivery pipe and diameter		

S. No.	Description	Units	Particulars
(d)	Weight	Kgs	
(e)	**Testing & Inspection:**		
	(i) Pump performance testing standard		
	(ii) Maximum Noise level	dB(A)	
	(iii) Maximum velocity of vibration	mm/sec	

2.1.7 Scum Pump set

S. No.	Description	Units	Particulars	
			Primary	**Secondary**
(a)	**General**			
	(i) Make			
	(ii) Model			
	(iii) Type			
	(iv) Quantity (W+S)	Nos.		
(b)	**Performance**			
	(i) Capacity	cum/hr		
	(ii) Total head	mlc		
	(iii) Speed	rpm		
	(iv) Overall efficiency (Pump + Motor)	%		
	(v) Motor Rating	kW		
(c)	**Materials of Construction**			
	(i) Casing			
	(ii) Impeller			
	(iii) Shaft			
	(iv) Mechanical Seal			
	(v) Lifting Chain and Guide Bar			
	(vi) Delivery pipe and diameter			
	(vii) Cooling Jacket			
(d)	Weight	Kgs		
(e)	**Testing & Inspection:**			
	(i) Pump performance testing standard			
	(ii) Maximum Noise level	dB(A)		

S. No.	Description	Units	Particulars	
			Primary	**Secondary**
	(iii) Maximum velocity of vibration	mm/sec		

2.1.8 Submersible Mixer

S. No.	Description	Units	Particulars			
(a)	**Submersible Mixer**					
	(i) Make					
	(ii) Type					
	(iii) Model					
	(iv) Quantity (W+S)	Nos.				
(b)	**Material of construction**					
	(i) Casing					
	(ii) Impeller					
	(iii) Shaft					
	(iv) Mechanical seal					
	(v) Guide mechanism with winch					
	(vi) Wire Rope					
	(vii) Lifting Davit					
(c)	**Design/Construction features**					
	(i) Impeller Diameter	mm				
	(ii) Rotation speed	rpm				
	(iii) Immersion depth	mm				
	(iv) Absorbed power	kW				
	(v) Motor rating	kW				
	(vi) Maximum Lifting weight	kgs				

2.1.9 SBR Decanter

S. No.	Sub S. No.	Description	Units	Particulars

S. No.	Sub S. No.	Description	Units	Particulars
(a)	(i)	Make		
	(ii)	Type		Floating or Electro-mechanically positioned with subsurface withdrawal and positive solids and scum exclusion mechanism. Fixed decanters or surface withdrawal not allowed.
	(iii)	Model		
	(iv)	Quantity (W+S)	Nos.	
	(v)	Overflow rate per Decanter	cum/hr	
	(vi)	Flow control valve		
		-Type		
		-Size		
		-Rating		
	(viii)	Noise level (dBA) at 1m distance from the machine	dB(A)	
	(ix)	Floatation unit dimension	mm	
	(xi)	Weir assembly Diameter x height x thickness	mm	
	(xiii)	Bowl length	mm	
	(xiv)	Taper Angle	degrees	
	(xv)	Decanter lowering speed	m/sec	
	(xvi)	Gear Box ratio		
	(xvii)	Overall Dimension	mm	
	(xviii)	Pipe Thickness Schedule used for Decanter assembly		
	(xix)	Weight	kgs	
		- Floatation unit		
		- Weir assembly		
		- Actuator		
	(xx)	Protection of Actuator		
(b)		**Material of Construction:**		
	(i)	Integral floatation unit		
	(ii)	Movable weir Assembly		
		-Weir Actuator		
		-Weir		
	(iii)	Decanter discharge pipe		
	(iv)	Flexible Joint for the discharge pipe		

S. No.	Sub S. No.	Description	Units	Particulars
	(vi)	Decanter mooring system		
	(v)	Decant flow control valve		
		- Body		
		- Disc		
		- Seat		
		- Shaft		
(c)	**I**	**Motor:**		
	(i)	Make		
	(ii)	Motor rating (Weir actuator)	kW	
	(iii)	Motor speed	rpm	
	(iv)	Make of Motor		
	(v)	Insulation class		
	(vi)	Enclosure		
	(vii)	Voltage & Frequency		
	II	**Motor – (Flow control valve actuator)**		
	(i)	Make		
	(ii)	Motor rating	kW	
	(iii)	Motor speed	rpm	
	(iv)	Make of Motor		
	(v)	Insulation class		
	(vi)	Enclosure		
	(vii)	Voltage & Frequency		

2.1.10 IFAS System

S. No.	Description	Units	Particulars
(a)	**General**		
	(i) Make		
	(ii) Model		
	(iii) Type		
	(iv) Quantity/ Volume	M3	
	(v) Frame Dimension		
(b)	**Materials of Construction**		
	(i) Frame Structure		
	(ii) IFAS media Material		
(c)	Approximate Weight	Kgs	

2.1.11 MBBR System

S. No.	Description	Units	Particulars
(a)	**General**		
	(i) Make		
	(ii) Model		
	(iii) Type		
	(iv) Quantity/ Volume	M3	
	(v) Dimension		
(b)	**Materials of Construction**		
	(i) Biomedia/MBBR Media & Shape		
	(ii) Aeration Grid (limited to MBBR Media Tank Area)		
	(iii) Sieve Assembly		
	(iv) Supports		
	(v) Bolts, Nuts & Fasteners		
	(vi) Washers, Flat		
(c)	Approximate Weight	Kgs	

2.1.12 Fine Bubble Air Diffusers

S. No.	Description	Units	Particulars
(a)	**General**		
	(i) Make		
	(ii) Model		
	(iii) Type		
	(iv) Diffuser OD x Length	mm x mm	
	(v) Aeration/SBR Basin Dimensions (L x W x SWD)	mm x mm	
	(vi) Design Air - Flow per Aeration/SBR Basin (Maximum/Average)	Nm^3/hr	
	(vii) Quantity per Aeration/SBR Basin	No.	
	(viii) Quantity in Aeration Basin Zone 1/Zone 2/...	No.	

S. No.	Description	Units	Particulars
	(ix) Weight per Diffuser	Kg	
	(x) Design air flow per diffuser	m^3/hr	
	(xi) Efficiency per diffuser	%	
(b)	**Diffuser Membrane**		
	(i) Type-self-cleaning (Yes/No)		
	(ii) No. of Membranes - Total	No.	
	(iii) Membrane Material		
	(iv) Means of attachment		
	(v) Membrane OD X Length	mm x mm	
	(vi) Pore size (Average)	mm	
	(vii) No. of Pores per length of Diffuser	No./m	
	(viii) Bubble size (Avg.)	mm	
(c)	**Diffuser Assembly**		
	(i) Make		
	(ii) Type		
	(iii) Length x Width	mm x mm	
	(iv) Material of Construction		
	(v) Coupling Type • Make • Model/Size		
	(vi) Diffuser Assembly Weight	Kg	
(d)	**Materials of Construction**		
	(i) Diffuser Tube		
	(ii) Membrane		
	(iii) Pipe clamps & Hardware		
	(iv) Pipe Grid		
(e)	**Performance**		
	(i) SOTE Oxygen transfer rate • Clear water • Field	%	
	(ii) Zone of influence	m	
	(iii) Zone of oxygenation	m	
	(iv) Depth of mixing	m	
	(v) Velocity thro' the Diffuser	m/sec	

S. No.	Description	Units	Particulars
	- Diffuser Head loss & Efficiency V/s Submergence - Curve attached. Diffuser Grid Drawing with retrievable arrangement details attached	Yes/No Yes/No	

2.1.13 Process Air Blowers

S. No.	Description	Units	Particulars
(a)	**General**		
	(i) Make		
	(ii) Type		
	(iii) Quantity (W+S)	Nos.	
	(iv) Capacity at NTP	m^3/min	
	(v) Design maximum discharge pressure	mlc	
	(vi) Efficiency	%	
	(vii) Speed, blower	rpm	
	(viii) Absorbed power	kW	
	(ix) Motor rating	kW	
	(x) Speed, motor	rpm	
	(xi) Noise level at Duty Point in dB(A) at 1.86 m from the unit	dB(A)	
	(xii) Vibration	mm/sec	
	(xiii) With Acoustic Hood	dB(A)	
	(xiv) Without Acoustic Hood	dB(A)	
	(xv) Weight – Blower	kgs	
	(xvi) Maximum lifting weight	kgs	
	(xvii) Dimensions (L x W x H)	m x m x m	
	(xviii) Coupling Type		
	(xix) Coupling Make		
	(xx) Cooling System		
(b)	**Material of construction:**		
	(i) Casing		
	(ii) Impeller		
	(iii) Shaft		
	(iv) Common Base frame		
	(v) Orientation		
(c)	**Acoustic Hood:**		
	(i) Type		
	(ii) Material of Construction		
(d)	**Inlet/Outlet silencer**		

S. No.	Description	Units	Particulars
	(i) Type		
	(ii) Make		
	(iii) Filter media		
	(iv) Mean air velocity	m/s	
(e)	**Noise reduction (mean) Air release valves**		
	(i) Number	Nos.	
	(ii) Diameter	mm	
	(iii) Type		
	(iv) Set pressure	bar	
	(v) Make		
(f)	**Delivery non-return valves**		
	(i) Number	Nos.	
	(ii) Diameter	mm	
	(iii) Type		
	(iv) Make		
(g)	**Delivery isolation valves**		
	(i) Number	Nos.	
	(ii) Diameter	mm	
	(iii) Type		
	(iv) Make		

2.1.14 Induction Motor for Process Air Blowers

Sr. No.	Description	Unit	Particulars
(a)	Make		
(b)	Type Designation		
(c)	Rating	kW	
(d)	Particulars at rated voltage and frequency:		
	(i) Starting time	Sec.	
	(ii) Starting current	% FL	
	(iii) Pull-out torque	% FLT	
	(iv) Pull-up torque	% FLT	

Sr. No.	Description	Unit	Particulars
(e)	Minimum voltage required under starting conditions to accelerate driven equipment to rated speed.	Volts	
(f)	Starting time at specified minimum starting voltage	Sec.	
(g)	Permissible running time at full load at minimum allowable voltage	Min.	
(h)	Locked rotor current withstands time (safe stall time) at 110% rated voltage		
	(i) At rated temp. (Hot)	Sec.	
	(ii) When cold	Sec.	
(i)	Stator thermal time constant	Sec.	
(j)	(i) Permissible no. of equally spread starts per hour under normal service conditions	No.	
	(ii) Permissible no. of starts in quick succession with cold machine at room temperature	No.	
	(iii) Permissible no. of hot restarts	No.	
	(iv) Starts per 8-hour period and 24-hour period	No.	
(k)	Space Heaters:		
	(i) Rated voltage, no., and location	Volts	
	(ii) Rating (Total)	KW	
(l)	Terminal box:		
	(i) Fault withstand capacity at rated voltage and duration	MVA for Secs.	
(m)	Insulation treatment		
(n)	**Embedded temperature detectors**		
(i)	Make & Type		
(ii)	Number		
(iii)	Resistance at 0^{o} C	Ohm	
(o)	**Efficiency**		
(i)	Full Load		
(ii)	¾ Load		

Sr. No.	Description	Unit	Particulars
(iii)	½ Load		
(iv)	At duty point		
(p)	**Power factor**		
(i)	Full Load		
(ii)	¾ Load		
(iii)	½ load		
(q)	Total guaranteed losses comprising iron loss, copper loss, friction, windage and stray losses	kW	
(i)	Break up : Iron loss	kW	
(ii)	Copper loss	kW	
(iii)	Friction, windage and stray losses	kW	
(r)	**Motor bearings**		
(i)	Permissible temperature rise for bearings	^{O} C	
(ii)	Design ambient temperature assumed for above	^{O} C	
(s)	Motor bearing lubrication system self-lubrication / forced oil lubrication		
(t)	**Stator core temperature detectors**		
(i)	Type and Make		
(ii)	Number		
(iii)	Resistance at 0^{o} C	Ohm	
(u)	Permissible vibration limits	mm/sec	
(v)	Wr^2 Value	kg-m^2	
(w)	Weight	Kg	

2.1.15 Waste Activated Sludge Pump Set

S. No.	Description	Units	Particulars
(a)	**General**		
	(i) Make		
	(ii) Model		
	(iii) Type		
	(iv) Quantity (W+S)	Nos.	
	(v) Tubular Installation		Yes/No

S. No.	Description	Units	Particulars
(b)	**Performance**		
	(i) Capacity	cum/hr	
	(ii) Total head	mlc	
	(iii) Speed	rpm	
	(iv) Overall efficiency (Pump + Motor)	%	
	(v) Motor Rating	kW	
(c)	**Materials of Construction**		
	(i) Impeller		
	(ii) Casing		
	(iii) Shaft		
	(iv) Mechanical seal		
	(v) Delivery pipe and diameter		
	(vi) Guide wire/rope & Lifting Chain		
	(vii) Dia of the tube/pipe & MOC		
(d)	Weight	Kg.	
(e)	Accessories as specified. (Provided / Not provided)		
(f)	Testing & Inspection:		
	(i) Pump performance testing standard		
	(ii) Maximum Noise level	dB(A)	
	(iii) Maximum velocity of vibration	mm/sec	
(g)	**Motor:**		
	(i) Make		
	(ii) Type		
	(iii) Model		
	(iv) Quantity (W+S)	Nos.	
	(v) Rating	kW	
	(vi) Weight	Kgs.	

2.1.16 Return Activated Sludge Pump Set

S. No.	Description	Units	Particulars
(a)	**General**		
	(i) Make		
	(ii) Model		
	(iii) Type		
	(iv) Quantity (W+S)	Nos.	

S. No.	Description	Units	Particulars
(b)	**Performance**		
	(i) Capacity	cum/hr	
	(ii) Total head	mlc	
	(iii) Speed	rpm	
	(iv) Overall efficiency (Pump + Motor)	%	
	(v) Motor Rating	kW	
(c)	**Materials of Construction**		
	(i) Impeller		
	(ii) Casing		
	(iii) Shaft		
	(iv) Delivery pipe and diameter		
	(v) Mechanical Seal		
	(vi) Cooling Jacket		
(d)	Weight	Kg	
(e)	Accessories and piping as specified (Provided / Not provided)		
(f)	**Testing & Inspection:**		
	(i) Pump performance testing standard		
	(ii) Maximum Noise level	dB(A)	
	(iii) Maximum velocity of vibration	mm/sec	
(g)	**Motor:**		
	(i) Make		
	(ii) Type		
	(iii) Model		
	(iv) Quantity (W+S)	Nos.	
	(v) Rating	kW	
	(vi) Weight	kgs	

2.1.17 Alum Dosing Pumps

S. No.	Description	Units	Particulars
(a)	**Pumps**		
	(i) Make		
	(ii) Type		
	(iii) Quantity (W+S)	Nos.	
	(iv) Model		
	(v) Capacity max/min	lpm	
	(vi) Head	mlc	
	(vii) Stroke adjustment	mm	

S. No.	Description	Units	Particulars
	(viii) Stroking speed max/min	spm	
	(ix) Casing material		
	(x) Diaphragm material		
	(xi) Shaft material		
	(xiii) Motor rating	kW	
	(xiv) Motor Make		
(b)	**Alum preparation Tank:**		
	(i) Make		
	(ii) Model		
	(iii) Quantity (W+S)	Nos	
	(iv) Size (Diameter x Height)	m x m	
	(v) Material of construction		
(c)	**Alum solution mixer**:		
	(i) Make		
	(ii) Model		
	(iii) Type		
	(iv) Quantity (W+S)	Nos	
	(v) Motor rating	kW	
	(vi) Motor speed	rpm	
	(vii) Mixer speed	rpm	
	(viii) Impeller material		
	(ix) Shaft material		

2.1.18 Chlorination System

S.No.	Description	Units	Particulars
(a)	**Automatic Changeover Device**		
	(i) Make		
	(ii) Type		
	(iii) Quantity (W+S)	Nos.	
	(iv) Model		
(b)	**Chlorinator**		
	(i) Make		
	(ii) Type		
	(iii) Quantity (W+S)	Nos.	
	(iv) Model		
	(v) Max capacity	kg/hr	
	(vi) Min Capacity	kg/hr	
	(vii) Accuracy as a percent of actual rate in the operating range	±%	
	(viii) Details of Instruments mounted		

S.No.	Description	Units	Particulars
	(ix) Cabinet Material		
(c)	**Chlorine load Cell (weighing scale)**		
	(i) Make		
	(ii) Type		
	(iii) Range		
	(iv) Quantity (W+S)	Nos.	
(d)	**Chlorine leak detector**		
	(i) Make		
	(ii) Type		
	(iii) Range		
	(iv) Quantity (W+S)	Nos.	
	(v) Location		
	(vi) Adjustable range of Alarm		
	(vii) State whether separate alarms for leak detection and leak detector equipment failure are provided		
(e)	**Chlorine Tonners and Roller supports**		
	(i) Make		
	(ii) Type		
	(iii) Quantity (W+S) - Chlorine tonners - Roller supports	Nos	
	(iv) Tonner capacity	Kgs	
	(v) Material of construction:		
	• Body		
	• Rollers		
	• Bush		
(f)	**Liquid Chlorine Pipe work, valves and fittings:**		
	(i) Make		
	(ii) Type		
	(iii) Quantity (W+S)	Nos	
	(iv) Rating		
(g)	**Material of construction:**		
	(i) Pipe		
	(ii) Fittings		
	(iii) Valves		
	(iv) Type		
	(v) Body		
	(vi) Shaft		
	(vii) Plug/Disc/Diaphragm		
(h)	**Valve Actuator:**		
	(i) Make		
	(ii) Type		

S.No.	Description	Units	Particulars
	(iii) Model		
(i)	**Pressure Gauges:**		
	(i) Make		
	(ii) Type		
	(iii) Range		
(j)	**Gas Chlorine Pipe work, valves and fittings:**		
	(i) Make		
	(ii) Type		
	(iii) Quantity (W+S)	Nos.	
	(iv) Rating		
(k)	**Material of construction:**		
	(i) Pipe		
	(ii) Fittings		
	(iii) Valves		
	(iv) Type		
	(v) Quantity	Nos.	
	(vi) Body		
	(vii) Shaft		
	(viii) Plug/Disc/Diaphragm		
(l)	**Valve Actuator:**		
	(i) Make		
	(ii) Type		
	(iii) Quantity (W+S)	Nos	
	(iv) Model		
(m)	**Pressure Gauges:**		
	(i) Make		
	(ii) Type		
	(iii) Range		
(n)	**Chlorine Ejectors:**		
	(i) Make		
	(ii) Type		
	(iii) Quantity (W+S)	Nos	
	(iv) Model	Nos.	
	(v) Rating		
	(vi) Material of construction:		
	(vii) End connections		
(o)	**Tonner lifting Beam with Hooks**		
	(i) Make		
	(ii) Quantity (W+S)	Nos.	
	(iii) Material of construction		

S.No.	Description	Units	Particulars
(p)	**Chlorine Tonner weighing equipment**		
	(i) Make		
	(ii) Type		
	(iii) Quantity (W+S)	Nos.	
	(iv) Range		
	(v) Accuracy		
(q)	**Safety Equipment:**		
	(i) Make:		
	(ii) Quantity:	Nos.	
	(iii) Type:		
	(iv) Self-contained breathing apparatus quantity		
	(v) Positive air - line breathing apparatus quantity		
	(vi) Instant action resuscitators quantity		
	(vii) Safety clothing complete set quantity		
	(viii) Emergency showers quantity		
	(ix) Eye Baths quantity		
	(x) Portable compressor, recharging cylinder, quick release coupling complete set quantity		
(r)	**Chlorine Gas scrubber:**		
	(i) Make		
	(ii) Type		
	(iii) Model		
	(iv) Quantity (W+S)	Nos.	
	(v) MOC of Tower		
	(vi) Weight	kg	
	(vii) Capacity	Kgs	
	(viii) Caustic pump capacity/head	Cum/hr/ m	
	(ix) Type & make		
	(x) Motor Rating	kW	
	(xi) MOC of Caustic Pump		
	- Casing		
	- Impeller		
	- Shaft		
	(xii) Blower capacity/pressure	Cum/hr/ bar	
	(xiii) Type & make		
	(xiv) MOC of Blower		
	- Casing		
	- Impeller		

S.No.	Description	Units	Particulars
	- Shaft		
	(xv) Agitator in the tank		Yes/No
	(xvi) Type & make		
	(xvii) MOC of agitator		
	(xviii) Motor Rating	kW	

2.1.19 Chlorine Booster Pump

S. No.	Description	Units	Particulars
(a)	**General**		
	(i) Make		
	(ii) Model		
	(iii) Type		
	(iv) Quantity (W+S)	Nos.	
(b)	**Performance**		
	(i) Capacity	cum/hr	
	(ii) Total head	mlc	
	(iii) Speed	rpm	
	(iv) Overall efficiency (Pump + Motor)	%	
	(v) Motor Rating	kW	
(c)	**Materials of Construction**		
	(i) Casing		
	(ii) Impeller		
	(iii) Shaft		
	(iv) Shaft Sleeve		
	(v) Mechanical Seal		
	(vi) Base Plate		
	(vii) Delivery pipe and diameter		
(d)	Weight	Kgs	
(e)	**Testing & Inspection:**		
	(i) Pump performance testing standard		
	(ii) Maximum Noise level	dB(A)	
	(iii) Maximum velocity of vibration	mm/sec	

2.1.20 Chlorine Building Ventilation

S. No.	Description	Units	Particulars
	Chlorine cylinder room		
(a)	**Exhaust fans:**		
	(i) Make		
	(ii) Model		
	(iii) Quantity(W+S)	Nos.	
	(iv) Capacity	m^3/s	
	(v) Speed	rpm	
	(vi) Motor rating	kW	
(b)	**Ducting:**		
	(i) Standard		
	(ii) Type		
	(iii) Dimension	m x m	
	(iv) Material		
(c)	**Chlorinator Room:**		
	(i) Exhaust fans		
	(ii) Make		
	(iii) Model		
	(iv) Quantity (W+S)	Nos.	
	(v) Capacity	m^3/s	
	(vi) Speed	rpm	
	(vii) Motor rating	kW	
(d)	**Ducting:**		
	(i) Standard		
	(ii) Type		
	(iii) Dimension	m x m	
	(iv) Material		

2.1.21 Disc Filter

Sr. No.	Description		Units	Particulars
(a)	**General**			
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity (W+S)	Nos	
(b)	**Performance**			
	(i)	Type of Tertiary Filter		
	(ii)	Design capacity	MLD	
	(iii)	No. of units/streams	Nos	
	(iv)	Design Capacity per unit/stream	MLD	

	(v)	No. of Filter Discs	Nos	
	(vi)	Max. Submergence	%	
	(vii)	MOC of Filter Media		
	(viii)	MOC of Filter Frame		
	(ix)	MOC of Segment Frame		
	(x)	MOC of Center Drum		
	(xi)	MOC of Main body (Frame)		
	(xii)	Filter Media Pore Size	microns	
(c)	**Filter Drive Unit**			
	(i)	Type of drive		
	(ii)	No. of drive unit	Nos	
	(iii)	Gear Ratio		
	(iv)	Rated Power	kW	
	(v)	Power Supply		
	(vi)	Motor Poles		
(d)	**Suction Cleaning Pump**			
	(i)	Type		
	(ii)	No. of pumps	Nos	
	(iii)	Capacity	m3/hr	
	(iv)	Head	M	
	(v)	Rated Power	kW	
	(vi)	Power Supply		
	(vii)	Motor Poles		

2.1.22 Gates for Disc filtration System

S. No.	Description	Units	Particulars
(a)	(i) Make		
	(ii) Model		
	(iii) Quantity (W+S)	Nos.	
	(iv) Service		
	(v) Type		
	(vi) Spindle Type		
	(vii) Size	mm x mm	
	(viii) Weight	kg.	
	(ix) Seating Head	m	
	(x) Unseating Head	m	
(b)	**Material of construction:**		
	(i) Wall Thimble		
	(ii) Gate		
	(iii) Frame		
	(iv) Spindle		
	(v) Stem coupling		
	(vi) Seating face		

S. No.	Description	Units	Particulars
	(vii) Wedge		
	(viii) Headstock		
	(ix) Gear House cover & stem guide		
	(x) Lift Nut		
	(xi) Fasteners & Anchors		
	(xii) Lifting mechanism, Gear House & stem guide		
(c)	**Gate Actuators +**		
	(i) Make		
	(ii) Type		
	(iii) Model		
	(iv) Service		
	(v) Number	Nos	
	(vi) Motor Rating	kW	
	(vii) Motor speed	rpm	
	(viii) Protection		
	(ix) Gear Reducer Make		
	(x) Type		

+Bidder to provide above details for each size of Gate and Service

2.1.23 EOT Crane

S. No.	Description	Units	Particulars	
(a)	**EOT Crane**			
	(i) Make			
	(ii) Type and class			
	(iii) Safe working Load	tonne		
	(iv) Hoist speed high/low	m/min		
	(v) Long Travel speed	m/min		
	(vi) Cross travel speed	m/min		
	(vii) Span	m		
(b)	**Hoisting Rope:**			
	(i) Diameter	mm		
	(ii) Construction			
	(iii) Quality of steel			
	(iv) Minimum Breaking Load	Kgs.		
	(v) Factor of safety			
(c)	**Motors for Hoist/Long travel/cross travel:**			
	(i) Make			
	(ii) Type			

S. No.	Description	Units	Particulars	
	(iii) Rating	kW		
(d)	**Details of Brakes for Hoist/cross travel/Long travel:**			
	(i) Make			
	(ii) Design Holding Torque	N-mm		
	(iii) Net weight	kgs		

2.1.24 Electric Hoist

S. No.	Description	Units	Particulars			
(a)	**Electric Hoist**					
	(i) Make					
	(ii) Type and class					
	(iii) Safe working Load	tonne				
	(iv) Hoist speed high/low	m/min				
	(v) Cross travel speed	m/min				
	(vi) Span	m				
(b)	**Hoisting Rope:**					
	(i) Diameter	mm				
	(ii) Construction					
	(iii) Quality of steel					
	(iv) Minimum Breaking Load	kgs				
	(v) Factor of safety					
(c)	**Motors for Hoist/ cross travel:**					
	(i) Make					
	(ii) Type					
	(iii) Rating	kW				
(d)	**Details of Brakes for Hoist/cross travel:**					
	(i) Make					
	(ii) Design Holding Torque	N-mm				
	(iii) Net weight	kgs				

2.1.25 Manual Hoists

Sr. No.	Description	Particulars							
		Units							
(a)	Capacity (tonnes)	tonnes							
(b)	Quantity	Nos							
(c)	Class								
(d)	Lift	m							
(e)	Span	m							
(f)	Length of the runway	m							
(g)	Hook type / Construction								
	- I.S. Specification No.								
	- Swivel type								
(h)	Wire rope construction and standard								
(i)	Specification/ Type of Rails for Long Travel								
(j)	**Painting**								
	- Type of primer coat								
	- No. of coats of paint								

2.1.26 Submersible Pump Set

S. No.	Description		Units	Particulars		
(a)	(i)	Tank capacity	cum			
	(ii)	Tank Dimensions	mm			
(b)	**Pump**					
	(i)	Pump Make				
	(ii)	Type				
	(iii)	Model				
	(iv)	Quantity (W+S)	Nos.			

S. No.	Description		Units	Particulars		
	(v)	Capacity	m^3/s			
	(vi)	Head	mlc			
	(vii)	Shut off Head	metres			
	(viii)	NPSH required	metres			
	(ix)	Submergence required	metres			
	(x)	Efficiency	%			
	(xi)	Absorbed power at duty point	kW			
	(xii)	Motor rating	kW			
	(xiii)	Speed	rpm			
(c)	**Material of construction:**					
	(i)	Casing				
	(ii)	Impeller				
	(iii)	Shaft				
	(iv)	Mechanical Seal				
	(v)	Lifting Chain and Guide Bar				
	(vi)	Cooling Jacket				
	(vii)	Discharge size	mm			
	(viii)	Suction size	mm			
	(ix)	Flange Drilling standard:				
	(x)	Weight (Pump + Motor)	kgs			
(d)	**Testing & Inspection:**					
	(i)	Pump performance testing standard				
	(ii)	Maximum Noise level	dB(A)			
	(iii)	Maximum velocity of vibration	mm/sec			
(e)	**Motor:**					
	(i)	Make				
	(ii)	Type				
	(iii)	Model				
	(iv)	Quantity (W+S)	Nos.			
	(v)	Rating	kW			
	(vi)	Weight	kgs			

2.1.27 Gates +

S. No.	Description	Units	Particulars
(a)	(i) Make		
	(ii) Model		
	(iii) Quantity (W+S)	Nos.	
	(iv) Service		
	(v) Type		
	(vi) Spindle Type		
	(vii) Size	mm x mm	
	(viii) Weight	kgs	
	(ix) Seating Head	m	
	(x) Unseating Head	m	
(b)	**Material of construction:**		
	(i) Wall Thimble		
	(ii) Gate		
	(iii) Frame		
	(iv) Spindle		
	(v) Stem coupling		
	(vi) Seating face		
	(vii) Wedge		
	(viii) Headstock		
	(ix) Gear House cover & stem guide		
	(x) Lift Nut		
	(xi) Fasteners & Anchors		
	(xii) Lifting mechanism, Gear House & stem guide		
(c)	**Gate Actuators +**		
	(i) Make		
	(ii) Type		
	(iii) Model		
	(iv) Service		
	(v) Number	Nos	
	(vi) Motor Rating	kw	
	(vii) Motor speed	rpm	
	(viii) Protection		
	(ix) Gear Reducer Make		
	(x) Type		

+Bidder to provide above details for each size of Gate and Service including modulating type of gates

2.1.28 Valves

S. No.	Description	Units	Particulars
(a)	**Butterfly valves: #**		
	(i) Make		
	(ii) Type		
	(iii) Model		
	(iv) Service		
	(v) Quantity (W+S)	Nos.	
	(vi) Size	mm	
	(vii) Rating	PN	
	(viii) Test pressure	bar	
	Material of construction		
	(ix) Body		
	(x) Disc		
	(xi) Sealing face		
	(xii) Shaft		
	Gear Reducers		
	(i) Make		
	(ii) Material		
	(iii) Flange Drilling standard		
(b)	**Butterfly Valve Actuators #**		
	(i) Make		
	(ii) Type		
	(iii) Model		
	(iv) Service		
	(v) Quantity (W+S)	Nos.	
	(vi) Motor rating	kW	
	(vii) Design Torque	N-m	
	(viii) Time for full open to full close	seconds	
(c)	**Plug valve**		
	(i) Make		
	(ii) Type		
	(iii) Model		
	(iv) Service		
	(v) Quantity (W+S)	Nos.	
	(vi) Size	mm	
	(vii) Rating	PN	
	(viii) Test pressure	bar	
	(ix) Body material		
(d)	**Non-return valves #**		
	(i) Make		
	(ii) Type		
	(iii) Model		

S. No.	Description	Units	Particulars
	(iv) Service		
	(v) Quantity (W+S)	Nos.	
	(vi) Size	mm	
	(vii) Rating	PN	
	(viii) Test Pressure	bar	
	(ix) Design standard		
	(x) Flange drilling standard		
(e)	**Material of construction:**		
	(i) Body		
	(ii) Disc/plates		
	(iii) Spring		
	(iv) Shaft		
(f)	**Sluice valves:#**		
	(i) Make		
	(ii) Type		
	(iii) Model		
	(iv) Service		
	(v) Number	Nos	
	(vi) Size	mm	
	(vii) Rating	PN	
	(viii) Test pressure	bar	
	Material of construction		
	(ix) Body		
	(x) Gate		
	(xi) Sealing face		
	(xii) Shaft		
	Gear Reducers		
	(i) Make		
	(ii) Material		
	(iii) Flange Drilling standard		
(g)	**Sluice Valve Actuators #**		
	(i) Make		
	(ii) Type		
	(iii) Number		
	(iv) Motor rating	kW	
	(v) Design Torque	N-m	
	(vi) Time for full open to full close	seconds	
(h)	**Knife Gate valves :#**		
	(i) Make		
	(ii) Type		
	(iii) Model		
	(iv) Service		
	(v) Number		

S. No.	Description	Units	Particulars
	(vi) Size	mm	
	(vii) Rating	PN	
	(viii) Test pressure	bar	
	(ix) Body material		
	(x) gate material		
	(xi) Sealing face material		
	(xii) Shaft material		
	(xiv) Gear Reducers:		
	(xv) Make		
	(xvi) Material		
	(xvii) Flange Drilling standard		
(i)	**Knife Gate Valve Actuators** #		
	(i) Make		
	(ii) Type		
	(iii) Number		
	(iv) Motor rating	kW	
	(v) Design Torque	kg-m	
	(vi) Time for full open to full close	seconds	
(j)	**Telescopic valve**		
	(i) Make		
	(ii) Quantity (W+S)	Nos.	
	(iii) Type		
	(iv) Pressure rating	PN	
	(v) Diameter /size	m	
	(vi) End connection		
	(vii) Material of construction:		
	(viii) Valve Body		
	(ix) Spindle		
	(x) Disc/gate		
	(xi) Lining		
	(xii) Fasteners		

Bidder to provide above details for each size, type of Valve and Service

2.1.29 Gravity Thickeners

S. No.	Description	Units	Particulars
(a)	(i) Make		
	(ii) Type		
	(iii) Quantity (W+S)	Nos.	
	(iv) Size (Diameter x SWD x FB)	m	
	(v) Scraper speed	rpm	

S. No.	Description	Units	Particulars
	(vi) Peripheral Velocity	m/s	
	(vii) Design Torque	N-m	
	(viii) Feed rate per thickener	cum/hr	
	(ix) Feed well size	mm	
	(x) Walkway (width x Height)	mm	
	(xi) Weir plate size (Thick x width)	mm	
(b)	**Surface preparation & protection:**		
	(i) Wetted parts		
	(ii) Exposed parts		
(c)	**Material of construction:**		
	(i) Bridge and Superstructure		
	(ii) Feed well		
	(iii) Shaft		
	(iv) Walkway Gratings		
	(v) Squeegees		
	(vi) Weir plate		
	(vii) Clamps & Hardware		
(d)	**Motor:**		
	(i) Motor rating	kW	
	(ii) Motor speed	rpm	
	(iii) Make		
	(iv) Protection		

2.1.30 Sludge Pumps

S. No.	Description		Units	Particulars		
(a)	(i)	Make				
	(ii)	Type				
	(iii)	Model				
	(iv)	Quantity (W+S)	Nos.			
	(v)	Capacity	cum/hr			
	(vi)	Head	mlc			
	(vii)	Efficiency	%			
	(viii)	Max. solid size	mm			
	(ix)	Speed	rpm			
	(x)	Motor rating	kW			
(b)	**Material of construction:**					
	(i)	Casing				
	(ii)	Rotor				
	(iii)	Stator				
	(iv)	Line shaft				

S. No.	Description		Units	Particulars		
	(v)	Sealing				
	(vi)	Base Plate				
(c)	**Construction Features**					
	(i)	Protection				
	(ii)	Flange drilling standard				
	(iii)	Suction diameter	mm			
	(iv)	Discharge diameter	mm			
	(v)	Coupling type/make				
(d)	**Motor**					
	(i)	Make				
	(ii)	Motor rating	kW			
	(iii)	Motor speed	rpm			
	(v)	Insulation class				
	(vi)	Enclosure				
	(vii)	Voltage & Frequency				

2.1.31 Polyelectrolyte Dosing Pumps

S. No.	Description	Units	Particulars
(a)	**Pumps**		
	(i) Make		
	(ii) Type		
	(iii) Quantity (W+S)	Nos	
	(iv) Model		
	(v) Capacity max/min	lpm	
	(vi) Head	mlc	
	(vii) Stroke adjustment	mm	
	(viii) Stroking speed max/min	spm	
	(ix) Casing material		
	(x) Diaphragm material		
	(xi) Shaft material		
	(xiii) Motor rating	kW	
	(xiv) Motor Make		
(b)	**Polyelectrolyte preparation Tank:**		
	(i) Make		
	(ii) Model		
	(iii) Quantity (W+S)	Nos.	
	(iv) Size (Diameter x Height)	m x m	

S. No.	Description	Units	Particulars
	(v) Material of construction		
(c)	**Poly solution Agitator**		
	(i) Make		
	(ii) Model		
	(iii) Type		
	(iv) Quantity (W+S)	Nos.	
	(v) Motor rating	kW	
	(vi) Motor speed	rpm	
	(vii) Mixer speed	rpm	
	(viii) Impeller material		
	(ix) Shaft material		
	(x) Solids recovery		

2.1.32 Centrifuges

S. No.	Description	Units	Particulars
(a)	(i) Make		
	(ii) Type		
	(iii) Model		
	(iv) Quantity (W+S)	Nos.	
	(v) Feed rate per centrifuge	cum/hr	
	(vi) Mass feed rate		
	(vii) % dried solids		
	(viii) Noise level (dBA) at 1m distance from the machine	dB(A)	
	(ix) Vibration level		
	(xi) Bowl Diameter	mm	
	(xiii) Bowl length	mm	
	(xiv) Taper Angle	degrees	
	(xv) Bowl speed	rpm	
	(xvi) Centrifugal force	Kgf	
	(xvii) Gear Box ratio		
	(xviii) Overall Dimension	mm	
	(xix) Weight (Centrifuge + Motor)	kgs	
	(xx) Protection of centrifuge		
(b)	**Material of Construction:**		
	(i) Bowl		
	(ii) Scroll		
	(iii) Blade		
	(iv) Scroll lead face protection		
	(v) Casing-Upper & Lower		
	(vi) Wear protection		

S. No.	Description	Units	Particulars
(c)	**Motor: - Main Drive**		
	(i) Make		
	(ii) Motor rating (Main Drive)	kW	
	(iii) Motor speed	rpm	
	(iv) Make of Motor		
	(v) Insulation class		
	(vi) Enclosure		
	(vii) Voltage & Frequency		
(d)	**Motor -Back drive**		
	(i) Make		
	(ii) Motor rating	kW	
	(iii) Motor speed	rpm	
	(iv) Make of Motor		
	(v) Insulation class		
	(vi) Enclosure		
	(vii) Voltage & Frequency		

2.1.33 Cake Hopper

S. No.	Description	Units	Particulars
(a)	(i) Make		
	(ii) Model		
	(iii) Type		
	(iv) Capacity	Kg/hr.	
	(v) Dimensions	mxm	
	(vi) Material of Construction		
(b)	**Motor**		
	(i) Make		
	(ii) Rating	kW	
	(iii) Speed	rpm	
	(iv) Insulation class		
	(v) Enclosure		
	(vi) Voltage & Frequency		

2.1.34 Screw Conveyor system

S. No.	Description	Units	Particulars
(a)	(i) Make		
	(ii) Model		
	(iii) Type		
	(iv) Quantity (W+S)	Nos	
	(v) Capacity	Kgs/hr	

S. No.	Description	Units	Particulars
	(vi) Length of conveyor	m	
	(vii) Angle of Inclination		
	(viii) Screw Dia	mm	
	(ix) Jointing detail/type		
	(x) Screw MOC		
	(xi) Screw speed		
(b)	**Motor**		
	(i) Make	`	
	(ii) Rating	kW	
	(iii) Speed	rpm	
	(iv) Insulation class		
	(v) Enclosure		
	(vi) Voltage & Frequency		

2.1.35 Air-conditioning Equipment (For SCADA Room)

S. No.	Description	Units	Particulars
(a)	(i) Make		
	(ii) Model		
	(iii) Type		
	(iv) Capacity	TR	
	(v) Quantity	Nos.	
	(vi) Motor Rating	kW	
	(vii) Air-Ducting:		
	(viii) Material		
	(ix) Size		
	(x) Quantity		
	(xi) Whether all the required accessories are provided	Yes/No	

2.1.36 Ultrafiltration system

S. No.	Description		Units	Particulars
(a)	(i)	Make		
	(ii)	Model		
	(iii)	Type of System (Submerged/ Pressurised)		
	(iv)	No. of Modules/Quantity		
	(v)	Membrane Material		
	(vi)	Membrane type		
	(vii)	Membrane Pore size		

S. No.	Description		Units	Particulars
	(viii)	Material of membrane Skid/Rack		
	(ix)	Membrane operating Conditions		
	(x)	Normal Filtration Rate (flux)	l/m2/hr	
	(xi)	One unit of Service Filtration Rate (flux)	l/m2/hr	
(b)	**Ultrafiltration system Pumps & Blowers**			
	(i)	Backwash Pump		
	(a)	Make		
	(b)	Type of Pump		
	(c)	Quantity (W+S)	Nos.	
	(d)	Capacity and Head	M3/hr & M	
	(e)	MOC of Pump		
	(ii)	Blower		
	(a)	Make		
	(b)	Type of Blower		
	(c)	Quantity (W+S)	Nos.	
	(d)	Capacity and Head	M3/hr & Bar	
	(e)	MOC of Blower		
	(iii)	CIP Pump		
	(a)	Make		
	(b)	Type of Pump		
	(c)	Quantity (W+S)	Nos.	
	(d)	Capacity and Head	M3/hr & M	
	(e)	MOC of Pump		
	(iv)	Type of Permeate Pump & Quantity (W+S)		
	(a)	Make		
	(b)	Type of Pump		
	(c)	Quantity (W+S)	Nos.	
	(d)	Capacity and Head	M3/hr & M	
	(e)	MOC of Pump		
	(v)	Ultrafiltration feed Pump		
	(a)	Make		
	(b)	Type of Pump		
	(c)	Quantity (W+S)	Nos.	
	(d)	Capacity and Head	M3/hr & M	
	(e)	MOC of Pump		
(c)	**Strainer or Pre filters**			
	(i)	Filter mesh size		
	(ii)	Type of Filter		
	(iii)	Filter make		

S. No.	Description		Units	Particulars
	(iv)	Inlet & Outlet Arrangement		
	(v)	Material of Strainer or Prefilters		
(d)		**Chemical/Acid Handling unit**		
		Dosing Pumps		
	(a)	Make		
	(b)	Type		
	(c)	Quantity (W+S)	Nos.	
	(d)	Model		
	(e)	Capacity max/min	lpm	
	(f)	Head	mlc	
	(g)	Stroke adjustment	mm	
	(h)	Stroking speed max/min	spm	
	(i)	Casing material		
	(j)	Diaphragm material		
	(k)	Shaft material		
	(l)	Motor rating	kW	
	(m)	Motor Make		
		Acid/Chemical Preparation Tank		
	(a)	Make		
	(b)	Model		
	(c)	Quantity (W+S)	Nos.	
	(d)	Size (Diameter x Height)	m x m	
	(e)	Material of construction		
(c)		Chemical mixer:		
	(a)	Make		
	(b)	Model		
	(c)	Type		
	(d)	Quantity (W+S)	Nos	
	(e)	Motor rating	kW	
	(f)	Motor speed	rpm	
	(g)	Mixer speed	rpm	
	(h)	Impeller material		
	(i)	Shaft material		

2.1.37 Odour Control System

S. No.	Description		Units	Particulars
				Head Works
(a)	(i)	Make		
	(ii)	Type of system		
	(iii)	Blower Type		
	(iv)	Quantity (W+S)	Nos.	
	(v)	Blower Capacity	cum/hr	
	(vi)	Pressure	bar	
	(vii)	Efficiency	%	
	(viii)	Power absorbed	kW	
	(ix)	Speed	rpm	
	(x)	Motor rating	kW	
	(xi)	Scrubber media		
	(xii)	Recirculation Pump Type		
	(xiii)	Capacity	cum/hr	
	(xiv)	Head	mlc	
	(xv)	Power absorbed	kW	
	(xvi)	Speed	rpm	

Note: Bidder shall furnish details in above table and write "NIL" wherever not applicable.

2.2 Mechanical Works TSPS / ISPS

2.2.1 Non-Clog Submersible Sewage Pumps –TSPS / ISPS

S. No.	Description	Units	Particulars	
(a)	**General**			
	(i) Make			
	(ii) Model			
	(iii) Quantity (W+S)	Nos.		
	(iv) Type			
(b)	**Performance**			
	(i) Capacity	cum/hr		
	(ii) Total Head	mlc		
	(iii) Efficiency	%		
	(iv) Maximum pump input at 50Hz for single pump operation	kW		
	(v) Shut off Head	mlc		
	(vi) Rated Speed	rpm		
	(vii) Size of solids that can be handled	mm		
(c)	**Design/Construction**			
	(i) Type of Impeller (enclosed / semi open)			
	(ii) No. of Impeller vanes	Nos		
	(iii) Impeller Diameter	mm		
	(iv) NPSHR	m		
	(iv) Minimum submergence required	mm		
	(v) Surface hardness of shaft sleeve	BHN		
	(vi) Discharge size	mm		
	(viii) Weight	kg		

S. No.	Description	Units	Particulars	
(d)	**Materials of Construction**			
	(i) Impeller			
	(ii) Casing			
	(iii) Shaft			
	(iv) Motor housing			
	(v) Cooling Jacket			
	(vi) Mechanical Seal (motor side)			
	(vii) Mechanical Seal (pump side)			
	(viii) Auto coupling with integral bend			
	(ix) Lifting chain			
	(x) Guide pipe			
	(xi) Guide Bracket			
	(xii) Fasteners			
(e)	**Testing and Inspection**			
	(i) Pump Performance testing Standard			
(f)	**Performance**			
	(i) Maximum velocity of vibration	mm/sec		
	(ii) Maximum noise level	dB(A)		

Note : TSPS - Terminal Sewage Pumping Station
ISPS – Intermediate Sewage Pumping Station

2.2.2 Submersible Induction Motor – TSPS / ISPS

S. No.	Description	Units	Particulars	
(a)	**General**			
(a)	Make			
(b)	Quantity (W+S)	Nos.		
(c)	Rating	kW		
(d)	Speed	rpm		
(e)	Type of Starter			
(f)	Efficiency • Full Load • ¾ Load	 % %		
(g)	Power Factor • Full Load • ¾ Load			
(h)	Class of Insulation			
(i)	Starting method			
(j)	Temperature rise by resistance method	°C		
(k)	Type of enclosure			
(l)	Degree of protection			
(m)	Weight	kg		
(n)	Cooling arrangement for motor			
(o)	Degree of Protection			

2.2.3 Mechanically Raked Bar Screen – TSPS / ISPS

S. No.	Description	Units	Particulars	
(a)	**General**			
	(i) Make			
	(ii) Model			
	(iii) Quantity (W+S)	Nos.		
	(iv) Type			
(b)	**Screen**			
	(i) Width	mm		
	(ii) Height	mm		

S. No.	Description	Units	Particulars	
	(iii) Bar size (front x back x depth)	mmxm mxmm		
	(iv) Clear space between bars at front end	mm		
	(v) Type or raking arrangement			
	(vi) Raking speed	m/min		
	(vii) Motor rating	kW		
(c)	**Materials of Construction**			
	(i) Frame			
	(ii) Rake carriage			
	(iii) Screen bars			
	(iv) Tines			
	(iv) Fasteners			
	(v) Canopy			
(d)	**Belt Conveyor System**			
	(i) Material of belt			
	(ii) Width of conveyor	mm		
	(iii) Speed of conveyor	m/sec		
	(iv) Thickness of belt and ply rating			
	(v) Make of the belt			
	(vi) Motor rating	kW		
(e)	**Screw Conveyor System**			
	(i) Make			
	(ii) Material			
	(iii) Speed	rpm		
	(iv) Motor rating	kW		
(f)	**Unit Control Panel**			

S. No.	Description	Units	Particulars	
	(i) Make			
	(ii) Circuit breaker rating	A		
	(iii) Over all dimensions	mm x mm x mm		
	(iv) Degree of protection			
	(v) Timer			
	• Make • Type			

2.2.4 Trash Rack (J-type coarse screen) for TSPS / ISPS

Sr. No.	Description		Units	Particulars	
	Design				
(a)	**Quantity (W)**		Nos		
	Size L x B X SWD +FB				
	Screening Quantity		Cum		
(a1)	**General**				
	(i)	Make			
	(ii)	Model			
	(iii)	Quantity (W+S)	Nos.		
	(iv)	Type			
(b)	**Trash rack**				
	(i)	Clear Spacing	mm		
	(ii)	Width	mm		
	(iii)	Height	mm		
	(iv)	Guide Rail Height	m		
	(v)	lifting arrangement	per min		
	(vi)	Water Level	m		
	(vii)	Inclination Angle	degree		
(c)	**Materials of Construction**				
	(i)	Frame			
	(ii)	Guide rail			
	(iii)	lifting arrangement			
(d)	**Screen solid Grabber Mechanism**				
	(i)	Make			

Sr. No.	Description		Units	Particulars	
	(ii)	Model			
	(iii)	Quantity (W+S)	Nos.		
	(iv)	Maximum weight to be lifted			
	(v)	Type of Operation			
	(vi)	Guide Rail Height			
	(vii)	Lifting arrangement			
	(viii)	Hoisting Speed	m/min		
	(ix)	Traversing Speed	m/min		
	(x)	Maximum Pressure			
		Material of construction			
	(i)	Grabbing unit			
	(ii)	Hydraulic hose drum			
	(iii)	Monorail Track			
	(iv)	Structural Columns			
	(v)	Cable Drums			
	(vi)	Hydraulic Power Pack			

2.2.5 Electrically Operated Hoist–Trash Screens (TSPS / ISPS)

S. No.	Description	Units	Particulars	
(a)	**Make**			
	(i) Crane			
	(ii) Chain pulley block			
	(iii) Trolley			
(b)	**Crane**			
	(i) Capacity-SWL	Tonne		
	(ii) Type			
	(iii) Lift	m		
	(iv) Span	m		
	(v) Hook approach	m		
	(vi) Rail size	kg/m		
	(vii) Crane girder size	mm		
	(viii) Type of brake			

S. No.	Description	Units	Particulars	
	(ix) Motors for Hoist/Long travel/cross travel :			
	(a) Make			
	(b) Type			
	(c) Rating	kW		

2.2.6 Electrically Operated Hoist–TSPS / ISPS

S. No.	Description	Units	Particulars	
(a)	**Make** (i) Crane			
	(ii) Chain pulley block			
	(iii) Trolley			
(b)	**Crane** (i) Capacity-SWL	Tonne		
	(ii) Type			
	(iii) Lift	m		
	(iv) Span	m		
	(v) Hook approach	m		
	(vi) Rail size	kg/m		
	(vii) Crane girder size	mm		
	(viii) Type of brake			
	(ix) Motors for Hoist/Long travel/cross travel :			
	(a) Make			
	(b) Type			
	(c) Rating	kW		

2.2.7 Gates+ (Inlet & Outlet Sluice Gates for Screen Channel, Inlet Sluice gate to Wet well, Isolation Sluice gate for Wet well, Weir Gate for Overflow) for TSPS / ISPS

S. No.	Description	Units	Particulars	
(a)	(i) Make			
	(ii) Model			
	(iii) Quantity (W+S)	Nos.		
	(iv) Service			
	(v) Type			
	(vi) Spindle Type			
	(vii) Size	mm x mm		
	(viii) Weight	kgs		
	(ix) Seating Head	m		
	(x) Unseating Head	m		
(b)	**Material of construction:**			
	(i) Wall Thimble			
	(ii) Gate			
	(iii) Frame			
	(iv) Spindle			
	(v) Stem coupling			
	(vi) Seating face			
	(vii) Wedge			
	(viii) Headstock			
	(ix) Gear House cover & stem guide			
	(x) Lift Nut			
	(xi) Fasteners & Anchors			
	(xii) Lifting mechanism, Gear House & stem guide			
(c)	**Gate Actuators +**			
	(i) Make			
	(ii) Type			
	(iii) Model			
	(iv) Service			
	(v) Number	Nos		
	(vi) Motor Rating	kW		
	(vii) Motor speed	rpm		
	(viii) Protection			
	(ix) Gear Reducer Make			
	(x) Type			

+Bidder to provide above details for each size of Gate and Service

2.2.8 Valves #

S. No.	Description	Units	Particulars	
(a)	**Non-return valves #**			
	(i) Make			
	(ii) Type			
	(iii) Model			
	(iv) Service			
	(v) Quantity (W+S)	Nos.		
	(vi) Size	mm		
	(vii) Rating	PN		
	(viii) Test Pressure	bar		
	(ix) Design standard			
	Material of construction:			
	(i) Body			
	(ii) Disc/plates			
	(iii) Spring			
	(iv) Shaft			
	(v) Flange drilling standard			
(b)	**Knife Gate valves :#**			
	(i) Make			
	(ii) Type			
	(iii) Model			
	(iv) Service			
	(v) Number			
	(vi) Size	mm		
	(vii) Rating	PN		
	(viii) Test pressure	bar		
	(ix) Body material			
	(x) Gate material			
	(xi) Sealing face material			
	(xii) Shaft material			
	(xiv) Gear Reducers			
	(xv) Gear Make			
	(xvi) Gear Material			
	(xvii) Flange Drilling standard			
(c)	**Knife Gate Valve Actuators #**			
	(i) Make			
	(ii) Type			
	(iii) Number			
	(iv) Motor rating	kW		
	(v) Design Torque	N-m		
	(vi) Time for full open to full close	Seconds		

Bidder to provide above details for each size, type of Valve and Service

2.2.9 Dewatering Pumps

S. No.	Description	Units	Particulars	
(a)	(i) Make			
	(ii) Type			
	(iii) Service/Location			
	(iv) Quantity (W+S)	Nos.		
	(v) Capacity	cum/hr		
	(vi) Head	mlc		
	(vii) Efficiency	%		
	(viii) Power absorbed	kW		
	(ix) Speed	rpm		
	(x) Motor rating	kW		

2.2.10 Valves in Pumping Main

S. No.	Description	Units	Particulars	
(a)	**Knife gate valve in Pumping Main**			
	(i) Make			
	(ii) Type			
	(iii) Model			
	(iv) Service			
	(v) Number	Nos		
	(vi) Size	mm		
	(vii) Rating	PN		
	(viii) Test pressure	bar		
	(ix) Body material			
	(x) gate material			
	(xi) Sealing face material			
	(xii) Shaft material			
	(xiv) Gear Reducers:			
	(xv) Make			
	(xvi) Material			
	(xvii) Flange Drilling standard			
(b)	**Knife Gate Valve Actuators** #			
	(i) Make			
	(ii) Type			
	(iii) Number			
	(iv) Motor rating	kW		
	(v) Design Torque	N-m		
	(vi) Time for full open to full close	Seconds		
(c)	**Air Valve in Pumping Main**			
	(i) Make			

S. No.	Description	Units	Particulars	
	(ii) Type			
	(iii) Number	Nos		
	(iv) Size	mm		
	(v) Rating	PN		
	(vi) Test pressure	bar		
	(vii) Body material			
	(viii) Float Material			
	(ix) Nozzle Material			
(d)	**Gate valve in Pumping Main**			
	(i) Make			
	(ii) Type			
	(iii) Model			
	(iv) Service			
	(v) Number	Nos		
	(vi) Size	mm		
	(vii) Rating	PN		
	(viii) Test pressure	bar		
	(ix) Body material			
	(x) gate material			
	(xi) Sealing face material			
	(xii) Shaft material			
	(xiv) Gear Reducers:			
	(xv) Make			
	(xvi) Material			
	(xvii) Flange Drilling standard			

2.2.11 Propeller Exhaust Fan

S. No	Description	Units	Particulars	
(a)	**Fan**			
	(i) Make			
	(ii) Make			
	(iii) Model			
	(iv) Impeller diameter	mm		
	(v) Impeller speed	rpm		
	(vi) Capacity	cum/hr		
	(vii) Static pressure	mmlc		
	(viii) Shaft power	W		
	(ix) Fan total efficiency	%		
(b)	**Motor**			
	(i) Make			
	(ii) Rating	kW		
(c)	**Overall weight**	kg		

2.2.12 Service Water Pumps

S. No.	Description	Units	Particulars	
(a)	(i) Make			
	(ii) Type			
	(iii) Service/Location			
	(iv) Quantity (W+S)	Nos.		
	(v) Capacity	cum/hr		
	(vi) Head	mlc		
	(vii) Efficiency	%		
	(viii) Power absorbed	kW		
	(ix) Speed	rpm		
	(x) Motor rating	kW		

Note: All Equipment shall be of reputed make and shall qualify the criteria specified in part 8 of this Bid document.

2.3 Process and CIVIL Units

S. No.	Units	WwTPs
2.3.1	**General and Process for WwTPs and TSPSs / ISPSs**	
1	Total head loss (m) in WwTPs (from water level in WwTPs Inlet Chamber to water level in CCT Effluent Channel) at peak flow with one unit of each process with multiple units out of service	
	(i) Lean Flow	
	(ii) Average Flow	
	(iii) Peak Flow	
	(iv) Peak flow with one unit of each process unit(s) out of service.	
2.3.2	**WwTPs**	
1)	WwTPs Inlet Chamber	
	(i) Size of channel, L*B*D (m)	
	(ii) Size of incoming pumping main (m)	
	(iii) No. and size of gated openings weir gates	
	(iv) Max, Average, and Min water levels (m)	
2)	Fine Screen Channels **OR Combi Unit**	
	(i) No. of units	
	(ii) Capacity of each unit (MLD)	
	(iii) Size of channel, L*B*D (m)	
	(iv) Max, Average, and Min water levels (m)	
	(v) Head loss (m)	
3)	Fine Screen Effluent/ Grit Basin Distribution Channel	
	(i) Size of channel L*B*D (m)	
	(ii) No. and size of gated openings and type of gates – Screen Effluent	
	(iii) No. and size of gated openings and weir gates – Grit Basin Influent	
	(iv) Max, Average, and Min water levels (m)	
4)	Vortex Grit Chamber	
	(i) Particle size to be removed (mm)	
	(ii) Specific gravity	
	(iii) Efficiency of removal (%)	
	(iv) Size of grit basin influent structure (m)	

S. No.	Units	WwTPs
	(v) Grit Basins - Number - Capacity, each MLD - Size, each, upper portion, Dia*D (m) - Size, each, lower portion, Dia*D (m)	
	(vi) Vortex Velocity (m/s)	
	(vii) Max, Average, and Min water levels in grit chamber m)	
5)	Grit Basin Effluent Channel/Parshall Flume Channel	
	(i) Size of channel (m)	
	(ii) No. and size of gated openings and type of gates	
	(iii) Max, Average, and Min water levels (m)	
	(iv) Size of Bypass channel/pipe (m), Material of Construction	
	(v) Size of Parshall Flume (m)	
6)	Bioreactor Basin Flow Distribution Box and Influent Channel to	
	- Size of channel - No. of distribution branches - Size of each branch, L*B*D (m) - No. and size of gated openings and weir gates (m) - Max, Average, and Min water levels (m)	
7)	Basins / Tanks	
	(i) - No. of basins - Length-to-width ratio for each basin	
	(ii) Process info - Total volume (m^3) - Total HRT (Hrs) - Total SRT (days) - Anaerobic SRT (days) - Anoxic SRT (days) - Aerobic SRT (days) - Overall Length and Width for all basins (m) - Overall F/M ratio (Kg BOD removed/ Kg MLVSS/ day) - Return Activated Sludge (RAS) ratio - RAS “From” and “To” locations	

S. No.	Units	WwTPs
	(iii) Pre-zone/Selector Zones - No. of zones per basin - Volume per basin (m^3) - Total volume (m^3) - volume as fraction of total volume - Side-Water Depth (SWD) (m) - MLSS (mg/l) - MLVSS (mg/l)	
	(vii) Hydraulic info - Aeration basin internal baffle weir elevations (m) - Max, Average, and Min water levels in all zones (m)	
8)	Bioreactor Basin Effluent Channel	
	- Size of channel, L*B*D (m) - No. and size of gated openings and weir gates (m)	
9)	Process Air Blower Building (i) Inside dimensions of blower room (Length x Width) (m) (ii) Inside dimensions of panel room (Length x Width) (m) (iii) Area allocated for loading / unloading (m^2) Height of Building (m)	
10)	Disc Filters	
	(i) Number of tanks	
	(ii) Size of Disc Filter Inlet Channel, L*B*H (m)	
	(iii) Size of Disc Filter Channel, L*B*H (m)	
	(iv) Size of Disc Filter Outlet Channel, L*B*H (m)	
	(v) No. and size of gated openings and weir gates (m)	
	(vi) Size of bypass channel/pipe (m), Material of Construction	
11)	Chlorine Contact Tank Influent Channel and flow distribution box - Size of channel - No. of branches - Size of each branch box L*B*D (m) - No. and size of gated openings and weir gates (m)	
12)	Chlorine Contact Tank(s)	
	(i) Number of tanks	

S. No.	Units	WwTPs
	(ii) Volume of each tank (m^3)	
	(iii) Total hydraulic retention time (all tanks) at peak flow (min.)	
	(iv) Overall Length and Width of all tanks (m)	
	(v) No. of passes per tank	
	(vi) Pass width (m)	
	(vii) Max, Average, and Min water depth (m)	
	(viii) Total length of travel of liquid per tank (m)	
	(ix) Effective length-to-width ratio	
13)	Chlorine Contact Tank Effluent Channel	
	- Size of channel (m) - No. and size of gated openings and weirs or gates (m) - Length and size, invert level of final effluent pipe/conduit to disposal point (m) - Size of outfall structure L*B*D (m)	
14)	Chlorination Building (i) Inside dimensions of chlorinator room (m) (ii) Inside dimensions of chlorine tonner room (m) Area allocated for loading / unloading (m^2) (iii) Height of Building (m)	
15)	Chemical Building (i) Inside dimensions of alum storage room (m) (ii) Inside dimensions of alum solution tank room (m) Area allocated for loading / unloading (m^2) (iii) Height of Building (m)	
16)	Centrifuge Feed Sump	
	(i) Sump inside dimensions, L*B*H (m)	
	(ii) Top slab elevations (m)	
	(iii) Dia. (mm) and length (m) of Sludge pipe	
17)	Centrifuge Feed Pump House	
	(i) Building inside dimensions, L*B*H (m)	
	(ii) All building slab elevations (m)	
	(iii) Dia. (mm) and length (m) of rising main	
18)	Centrifuge Building (G+1)	
	(i) Building inside dimensions, L*B*H (m)	
	(ii) All building slab elevations (m)	
19)	Scum Pit	
	(i) Sump inside dimensions, L*B*H (m)	
	(ii) Top slab elevations (m)	

S. No.	Units	WwTPs
	(iii) Dia. (mm) and length (m) of Scum pipe	
20)	Overflow Chambers	
	(i) Chamber inside dimensions, L*B*H (m)	
	(ii) Top slab elevations (m)	
	(iii) Dia. (mm) and length (m) of Overflow pipe	
21)	Treated Water Sump and Pumping Station	
	(i) Full dimensions of structure (m)	
	(ii) All structural slab elevations (m)	
	(iii) Dia. (mm) and length (m) of rising main	
22)	Plant Drain Sump and Pumping Station	
	(i) Full dimensions of structure (m)	
	(ii) All structural slab elevations (m)	
	(iii) Dia. (mm) and length (m) of rising main	
23)	Admin Building (G+1)	
	(i) Inside Dimensions of building (m x m) (ii) Inside Dimensions of office room (m x m) (iii) Inside Dimensions of SCADA room (m x m) (iv) Inside Dimensions of laboratory room (m x m) (v) Inside Dimensions of conference hall (m x m) (vi) Inside Dimensions of administrative room (m x m) (vii) Inside Dimensions of store room (m x m) (viii) Inside Dimensions of Pantry/Kitchen (m x m) (ix) Inside Dimensions of Toilet (m x m) (x) Inside Dimensions of other room if any (m x m) (xi) Height of Building (m)	
24)	Maintenance Workshop/ Store room	
	(i) Inside Dimensions of Maintenance Workshop/Store room (m x m)	
	(ii) Height of Building (m)	
25)	Area allocated for transformer yard (m^2)	
26)	Size of Electrical Sub-Station (m x m x m)	
27)	Size of DG set room (m x m x m)	
28)	Width and Height of entrance gate (m) and wicket gate (m) with arrangement for cow guard	
29)	Length and Height of Compound Wall-Total, L*H (m)	
30)	Size of security Room (m x m x m)	
31)	Area allocated for green belt (m^2)	
32)	Area allocated for two wheeler and four wheeler parking (m^2)	
33)	Width and length of approach road to site (m)	
34)	Width and length of roads inside the plant (m)	

S. No.	Units	WwTPs
35)	Internal drainage, water supply, and waste water disposal	
	(i) Storm water drain (size, length in m)	
	(ii) Water Supply and Sewerage Provision - Capacity and size of water storage tank (m^3) - Capacity and size of overhead tank (m^3) - Capacity and size of septic tank (if required) (m^3)	
	(iii) Nos. and size of Culverts, road crossing, etc.	
36)	Reclamation / Site Development – As Applicable	
	(i) Proposed area of Reclamation (m^2)	
	(ii) Top levels after Reclamation (m)	
	(iii) Average depth of filling (m)	
	(iv) Total quantity of earth required (m^3)	
	(v) Side slope of the filling	
	(vi) Slope protection measures	
	(vii) Proposed compaction equipment to be deployed (Type and No.)	
	(viii) Test apparatus to be provided in field soil laboratory	
	(ix) Proposed open channel dimension - Top width (m) - Bottom width (m) - Side slope - Longitudinal slope - Length (m) - Height	
	(x) Proposed Nalla Diversion Dimension - Top width (m) - Bottom width (m) - Side slope - Longitudinal slope - Length (m) - Height	
	(xi) Bottom slope protection for open channel	
	(xii) Proposed equipment (type and number) for excavation, handling, transporting	
	(xiii) Borrow pit - Name of the Location (s) - Area (m^2) - Type of soil in general	
37)	Primary Clarifier Distribution Structure	

S. No.	Units	WwTPs
	- Size of inlet channel - No. of branches - Size of each branch, L*B*D (m) - Size of weir gates (m)	
38)	Primary clarifiers	
	- No. of clarifiers - Capacity, each MLD - Diameter each (m) - Surface area each (m^2) - HRT (Hrs) - Side water depth (m) - Surface overflow rate ($m^3/m^2/day$) - Bottom floor slope - Inlet Pipe Diameter (From distribution structure to Centre column) (mm) - Centre column diameter (mm)	
39)	Primary Sludge Pumping Station	
	- Pump station building size, L*B*H (m) - All building slab elevations (m) - Dia. (mm) and length (m) of rising main	
	(i) Inside dimensions of alum storage room (m) (ii) Inside dimensions of alum solution tank room (m) Area allocated for loading / unloading (m^2) (iii) Height of Building (m)	
40)	Gravity Sludge Thickener Distribution Structure	
	- Size of inlet chamber (m) - No. of branches - Size of each branch, L*B*D (m) - No. and size of gated openings and weir gates (m)	
41)	Gravity sludge thickeners - No. of thickeners - Diameter each (m) - Surface area each (m^2) - Side water depth (m) - Surface overflow rate ($m^3/m^2/day$) - Solids loading rate ($Kg/m^2/day$) - Bottom floor slope	
42)	Thickened Sludge Pumping Station	

S. No.	Units	WwTPs
	(i) Building inside dimensions, L*B*H (m)	
	(ii) All building slab elevations (m)	
	(iii) Dia. (mm) and length (m) of rising main	
48)	Reuse Tank & Reuse Building	
	(i) Building inside dimensions, L*B (m)	
	(ii) Height of Building (m)	
	(iii) All building slab elevations (m)	
	(iv) Dimensions of all internal areas and spaces within building (m)	
43)	Reuse GLR and Pumping Station	
	Full dimensions of structure (m)	
	All structural slab elevations (m)	
44)	Miscellaneous	
	The Bidder shall list here details of any other / additional items required for a complete installation.	

3.4.3	**Terminal / Intermediate Sewage Pumping Stations (TSPS / ISPS)**		
(a)	Diameter and Height of inlet manhole		
(b)	Coarse Screen Influent Channel		
	(i) Size of inlet channel (m)		
	(ii) Size of incoming sewer (m)		
	(iii) Nos. and size of gated openings and type of gates		
	(iv) Max, Average, and Min water levels (m)		
(c)	Coarse Screen Channels		
	(i) No. of units		
	(ii) Capacity of each unit in MLD		
	(iii) Size of channel L*B*D (m)		
	(iv) Clear opening of bars in screen at screen channel		
	(v) Max, Average, and Min water levels (m)		
	(vi) Head loss (mm)		
(d)	Coarse Screen Effluent Channel		
	(i) Size of inlet channel (m)		

	(ii) Nos. and size of gated openings and type of gates		
	(iii) Max, Average, and Min water levels (m)		
	(iv) Size of Plant Bypass		
(e)	TSPS Wet Well inside dimensions and bottom slab invert elevation, all in meters		
(f)	TSPS Valve Chamber inside dimensions and bottom slab invert elevation, all in meters		
(g)	TSPS Superstructure dimensions (L/W/Dia, roof height) in meters		
(h)	Size of 11 KV Switch Gear room (m x m x m)		
(i)	Area allocated for transformer yard and 11 KV two pole structure (m^2)		

End of Schedule II

TECHNICAL SCHEDULE III

Instrumentation, Control & Automation Equipment's for WwTPs

3.1 Instrumentation & Control Equipment's

Note: The bidder shall provide complete information along with product brochures in the schedule as required under the bid specifications for technical qualification**.**

Sr. No.	Description	Unit	Particulars
3.1.1	**Level Measuring System**		
(a)	Type of Transmitter Measuring Principle Accuracy Make and Model Beam Angle Country of Origin		
(b)	Differential Level Transmitter Type of Transmitter Measuring Principle Accuracy Make and Model Beam Angle Country of Origin		
(c)	Conductivity Type Make and Model No. of electrodes Country of Origin		

Sr. No.	Description	Unit	Particulars
(d)	Level Gauges Make and Model Type Country of Origin		
3.1.2	**Digital Level Display Unit**		
(a) (b)	Make and Model Country of Origin		
3.1.3	**Pressure Gauges**		
(a)	Make and Model		
	Accuracy		
(b) (c) (d)	Range Country of Origin	kg/cm^2	
3.1.4	**Pressure Transmitter with local indication**		
(a)	Make and Model		
	Accuracy		
(b) (c) (d)	Range Country of Origin	kg/cm^2	
3.1.5	**Digital Pressure Indicator**		
(a)	Make and Model		
3.1.6	**Pressure Switches**		
(a)	Range		
(b)	Make and Model		

Sr. No.	Description	Unit	Particulars
(c)	Country of Origin		
3.1.7	**Flow Measuring System**		
(a)	**Electromagnetic Flowmeter** Make and Model		
	Measuring Principle		
	Accuracy		
(b)	Flow integrator and display unit Make and Model Country of Origin		
(c)	**Thermal Mass Flowmeter** Make and Model Accuracy Flow integrator and Display Unit Country of Origin		

Sr. No.	Description	Unit	Particulars
(d)	**Open Channel Flow Measuring System** Make / Model Type Quantity Accuracy Country of Origin		
(e)	**Flow Switches** Make / Model Type Quantity Accuracy Country of Origin		

Sr. No.	Description	Unit	Particulars
3.1.8	**Weight Indicator cum Transmitter** Make / Model Type Quantity Accuracy Country of Origin		
3.1.9	**Instrument Junction Boxes** Make and Model Instrument enclosures Country of Origin		
3.1.10	**Instrument Enclosures** Make and Model Instrument enclosures IP Rating Country of Origin		
3.1.11	**Control & Automation System:** **(Hot Standby CPU) Programmable Logic Controller For WASTEWATER TREATMENT PLANT**		

Sr. No.	Description	Unit	Particulars
(a)	Make and Model: Hot standby Offered at WASTEWATER TREATMENT PLANT: Country of Origin:		
(b)	(i) Digital Inputs (ii) Model No (iii) Type (iv) Country of origin (v) Series similar to CPU.	Nos.	
(c)	(i) Digital outputs (ii) Model No (iii) Type (iv) Country of origin (v) Series similar to CPU.	Nos.	
(d)	(i) Analog Inputs (ii) Model No (iii) Type (iv) Country of origin (v) Series similar to CPU.	Nos.	

Sr. No.	Description	Unit	Particulars
(e)	(i) Analog outputs (ii) Model No (iii) Type (iv) Country of origin (v) Series similar to CPU.	Nos.	
(f)	**Internal Wiring Master PLC cum RIO Panels [conformal coating with sand blasting with Double Door Glassy Window]** (i) IP-Class: (ii) Material of Construction:		
3.1.12	**Memory**		
3.1.13	**Redundant Power Supply Modules** (i) Make (ii)Model No (iii) Country of Origin		
3.1.14	**Communication Modules** (i) Make (ii) Model No (iii) Country of Origin		

Sr. No.	Description	Unit	Particulars
3.1.15	Portable Industrial Programming Unit (Laptop-16" screen) loaded with licensed latest Windows operating system, PLC programming software & SCADA software, MS Office, Antivirus software, with all accessories required to connect to PLC and to monitor &control the plant if required, etc)		
3.1.16	Interface/integration Redundant GPRS (Dual SIM) communication equipment with ISPS & MIS-2 contracts (i) Make & Model: (ii) Country of Origin: (iii) Redundancy offered:		
3.1.17	**HMI (Minimum10'' & 15") for PLC & RIO Panels**		
(a)	Software Details: Version No:		

Sr. No.	Description	Unit	Particulars
(b)	Hardware Details (i) CPU Configuration (ii) Make /Model (iii) Touch Screen Color (iv) Monitor Configuration (v) Country of Origin (vi) HMI Size for Vendor Packages: (vii) HMI Size for RIO Panels:		
3.1.18	Printers (inclusive of All-in-one printer) - ONLINE - Country of Origin	Nos	

Sr. No.	Description	Unit	Particulars
3.1.19	**SCADA & Historian Software Packages** **SCADA software:** Version: Number of Tags: Licensed without any Timebound (Yes / No): Country of Origin: **Historian Software:** Version: Number of Tags: Licensed without any Timebound (Yes/ No): Country of Origin: PLC Programming Software: Version: FBD Supported & Included: Make & Origin(Contractor shall name Make & Origin without fail)		

Sr. No.	Description	Unit	Particulars
3.1.20	SCADA Server Hardware Details CPU Configuration Make /Model Monitor size Monitor make Make Country of origin		
3.1.21	SCADA clients/Operator machines Hardware Details (i) CPU Configuration (ii) Make /Model (i) Monitor size (ii) Monitor make (iv) Country of Origin		
3.1.22	Historian Operator Workstation (i) CPU Configuration (ii) Make /Model (iii) Monitor size (iv) Monitor make (iv) Country of Origin		

Sr. No.	Description	Unit	Particulars
3.1.23	**Console Systems for Operator Workstations, Printers etc..** (i) Make (i) Model (ii) Country of Origin (iii) Qty.	Nos.	
3.1.24	**Large screen display, 55" in array of 2x3 configuration** Make and Model:		
	Dimension/Size:		
	Video switcher /Controller Considered:		
	Country of Origin:		
3.1.25	**Temperature Scanner**		
	Make and Model		
	Accuracy		
	No. of Channels		
	Country of Origin		
	Number of alarm contacts per channel		
3.1.26 (a) (b)	**Temperature Gauges** Make and Model Accuracy		
(c)	Country of Origin		

Sr. No.	Description	Unit	Particulars
3.1.27	**Temperature Transmitters**		
(a)	Make and Model		
(b)	Accuracy		
(c)	Type		
(d)	Country of Origin		
3.1.28	**Managed Industrial Type Ethernet Switches** (i) Make /Model (ii) No of Ports (iii) Redundancy (iv) Country of Origin		
3.1.29	**Fiber Optic Cables** Make /Model Mode- Redundancy- Number of Fibers-		

Sr. No.	Description	Unit	Particulars
3.1.30	**CCTV Workstation Details** (i) CPU Configuration (ii) Make /Model (iii) Monitor make (iv) Monitor Size (i) Country of Origin		
3.1.31	**Uninterruptable Power Supply for WASTEWATER TREATMENT PLANT** Make and Model		
	Capacity		
	Backup time		
	No of batteries		
	Country of Origin:		
3.1.32	**Surge Protection Devices**		
(a) (b) (c)	Surge Rating Make/Model Country of Origin:	kA	

Sr. No.	Description	Unit	Particulars
3.1.33	**Instrumentation and Control Cables**		
(a)	Make		
(b)	No of Cores		
(c)	Type		
(d)	Country of Origin		
(e)	Armoured cables are considered:		
3.1.34	**Cable trays** Make: Type: Country of Origin:		
3.1.35	**Instrument Enclosures** Make: IP Rating: Country of Origin:		
3.1.36	**Fire alarm detection & Suppression system** (a) Make & model: (b) Country of Origin:		
3.1.37	**AC distribution board for Instrumentation & Control and Telemetry System**		
(a)	Make and Model		
(b)	Pre-fabricated		
(c)	Country of Origin		

Sr. No.	Description	Unit	Particulars
3.1.38	**Lab Instruments** Make and model (List all lab equipment with make & model) LIMS software: Make and model: Confirm LIMS software connected to SCADA system: Country of Origin		
3.1.39	**All Weather Refrigerated Auto Sampler** Make and model Technical Details Country of Origin		
3.1.40	**Online Real Time Multi-Parameters Water Quality Systems at Inlet & Outlet of WASTEWATER TREATMENT PLANT** Make and model Technical Details Country of Origin		
3.1.41	**Online Analytical Instrumentation**		
(a)	**Turbidity Measurement system** Make and model Technical Details Country of Origin		

Sr. No.	Description	Unit	Particulars
(b)	**pH Measurement system** Make and model Technical Details Country of Origin		
(c)	**Chlorine Measurement system** Make and model Technical Details Country of Origin		
(d)	**Dissolved Oxygen Measurement system** Make and model Technical Details Country of Origin		
(e)	**Suspended Solids Measurement system** Make and model Technical Details Country of Origin		
(f)	**TDS Measurement system** Make and model Technical Details Country of Origin		

Sr. No.	Description	Unit	Particulars
(g)	**ORP Measurement system** Make and model Technical Details Country of Origin		
(h)	**Conductivity Type Measuring system** Make and model Technical Details Country of Origin		
3.1.42	**Air Cooled split Air Conditioner complete with IDU and ODU** Make and Model Country of Origin		
3.1.43	**CCTV SURVILLANCE SYSTEMS:** Make: Model: Country of Origin: **TECHNICAL DETAILS:**		
3.1.44	**Instrument Earthing** Make: Model: Country of Origin: TECHNICAL DETAILS:		

Instrumentation, Control & Automation Equipment's for Intermediate Sewage Pumping Stations (ISPSs)

3.2 Instrumentation & Control Equipment's

Sr. No.	Description	Unit	Particulars
3.2.1	**Level Measuring System**		
(a)	Type of Transmitter Measuring Principle Accuracy Make and Model Beam Angle Country of Origin		
(c)	**Conductivity Type** Make and Model No. of electrode Country of Origin		
(d)	**Float type Level Gauge** Make and Model Float Material Country of Origin		
3.2.2	**Digital Level Display Unit**		
3.2.3	**Pressure Gauges**		
	Make and Model		
	Accuracy		
	Range Country of Origin	kg/cm^2	
3.2.4	**Pressure Transmitter**		

Sr. No.	Description	Unit	Particulars
	Make and Model		
	Accuracy		
	Range Country of Origin	kg/cm^2	
3.2.5	**Digital Pressure Indicator**		
	Make and Model		
3.2.6	**Pressure Switches**		
	Make and Model Country of Origin		
3.2.7	**Flow Measuring System**		
(a)	**Electromagnetic Flowmeter** Make and Model Accuracy Country of Origin		
3.2.8	**Instrument Junction Boxes** Make and Model Country of Origin		
3.2.9	**Control & Automation System:** **(Standalone) Programmable Logic Controller ISPS**		
(a)	**Make and Model:** Standalone at ISPS: Country of Origin:		

Sr. No.	Description	Unit	Particulars
(b)	(i) Digital Inputs (ii) Model No (iii) Type (iv) Country of origin (v) Series similar to CPU.	Nos.	
(c)	(i) Digital Outputs (ii) Model No (iii) Type (iv) Country of origin (v) Series similar to CPU.	Nos.	
(d)	(i) Analog Inputs (ii) Model No (iii) Type (iv) Country of origin (v) Series similar to CPU.	Nos.	
(e)	(i) Analog Outputs (ii) Model No (iii) Type (iv) Country of origin (v) Series similar to CPU.	Nos.	

Sr. No.	Description	Unit	Particulars
(d)	**Internal Wiring PLC Panel [conformal coating with sand blasting with Doble Door Glassy Window]** (i) IP-Class: (ii) Material of Construction:		
(f)	**Memory**		
(g)	**Power Supply Module** (i) Make (ii)Model No (iii) Country of Origin		
(h)	**CPU, Communication Modules** (i) Make (ii) Model No (iii) Country of Origin		
(i)	**Interface/integration GPRS (Dual SIM) communication equipment with WASTEWATER TREATMENT PLANTs & MIS-2 contract** (i) Make & Model: (ii) Country of Origin:		
3.2.10	**HMI (Minimum 15") for PLC**		

Sr. No.	Description	Unit	Particulars
(a)	Software Details: Version No: Country of Origin		
(b)	Hardware Details CPU Configuration Make /Model Monitor Configuration Country of Origin		
3.2.11	**Managed Industrial Type Ethernet Switches** Make /Model No of Ports Country of Origin		
3.2.12	**Uninterruptable Power Supply** Make and Model		
	Capacity		
	Backup time considered		
	No of batteries		
	Country of Origin:		
3.2.13	**Surge Protection Devices** Surge Rating Make/Model Country of Origin	kA	

Sr. No.	Description	Unit	Particulars
3.2.14	**Instrumentation and Control Cables** Make No of Cores Type Country of Origin Armoured cables are considered:		
3.2.15	**Cable trays** Make: Type: Country of Origin		
3.2.16	**Instrument Enclosures** Make: IP Rating : Country of Origin		
3.2.17	**Air Cooled split Air Conditioner complete with IDU and ODU** Make and Model Country of Origin		
3.2.18	**AC distribution board for Instrumentation & Control and Telemetry System** Make and Model Pre-fabricated Country of Origin		

Sr. No.	Description	Unit	Particulars
3.2.19	**CCTV SURVILLANCE SYSTEMS:** Make: Model: Country of Origin: Technical Details:		
3.2.20	**Instrument Earthing** Make: Model: Country of Origin: TECHNICAL DETAILS:		

Instrumentation, Control & Automation Equipment's for Lifting Pumping Stations (LPSs)

3.3 Instrumentation Equipment

Sr. No.	Description	Unit	Particulars
3.3.1	**Conductivity Type** Make and Model No. of electrode Country of Origin		
3.3.2	**Pressure Gauges**		
	Make and Model		
	Accuracy		
	Range Country of Origin	kg/cm^2	
3.3.3	**Electromagnetic Flowmeter**		

Sr. No.	Description	Unit	Particulars
	Make and Model Accuracy Country of Origin		
3.3.4	**Uninterruptable Power Supply** Make and Model		
	Capacity		
	Backup time considered		
	No of batteries		
	Country of Origin:		
3.3.5	**Surge Protection Devices** Surge Rating Make/Model Country of Origin	kA	
3.3.6	**Instrumentation and Control Cables** Make No of Cores Type Country of Origin Armoured cables are considered:		
3.3.7	**Cable trays** Make: Type: Country of Origin		

Sr. No.	Description	Unit	Particulars
3.3.8	**Air Cooled split Air Conditioner complete with IDU and ODU** Make and Model Country of Origin		
3.3.18	**AC distribution board for Instrumentation & Control and Telemetry System** Make and Model Pre-fabricated Country of Origin		
3.3.19	**Instrument Earthing** Make: Model: Country of Origin: TECHNICAL DETAILS:		

End of Schedule III

TECHNICAL SCHEDULE IV

ELECTRICAL WORKS

(To be completed by the Bidder)

4.1 The Bidder shall submit the filled in Technical Particulars for all the Equipment / Items as indicated under item no. 4.1.1 to item no 4.1.15 in the prescribed format separately for Wastewater Treatment Plants at various locations.

4.1.1 11 kV Metal Enclosed Switchboards

Sr. No.	Description	Unit	Technical Particulars
4.1.1.1	Make		
4.1.1.2	Type		
4.1.1.3	Applicable Standards		
4.1.1.4	Quantity	No	
4.1.1.5	Dimensions	mm	
4.1.1.6	**Switchgear cubicles and Bus bar ratings**		
(a)	Rated voltage, phases and frequency		
(b)	System Neutral Earthing		
(c)	Maximum system voltage	kV	
(d)	One minute power frequency withstand voltage	kV (rms)	
(e)	12/50 μsec impulse withstand voltage	kV (peak)	
(f)	Short circuit withstand		
	(i) Short time (1 sec) at rated voltage	kA (rms)	
	(ii) Dynamic rating	kA (peak)	
(g)	Reference ambient temperature	°C	
(h)	Maximum temperature of bus bars droppers connectors and contacts at continuous current rating under site reference ambient temperature	°C	
(i)	Continuous current rating of bus bar	A	
(j)	Bus bar material		
(k)	Bus bar Insulation		

Sr. No.	Description		Unit	Technical Particulars
(l)	Cable entry			
(m)	Cable type for Incoming and Outgoing feeders			
4.1.1.7	**Switchgear constructional Requirement**			
(a)	Thickness of sheet steel Frame, Frame enclosures, doors, covers and partitions		mm	
(b)	Degree of protection			
(c)	Colour finish shade			
(d)	Earthing bus	i) Material		
		ii) Size	mm x mm	
(e)	Earthing conductor	i) Material		
		ii) Size	mm x mm	
4.1.1.8	**Breaker Particulars**			
(a)	Circuit breaker type			
(b)	Voltage, phases and frequency			
(c)	Rated operating duty			
(d)	Rated current at reference ambient temperature			
	(i) Incoming breakers		A	
	(ii) Outgoing breakers		A	
(e)	Rated breaking capacity		kA (rms)	
(f)	Rated making current		kA (peak)	
(g)	Short time current withstand for 1 sec duration		kA (rms)	
(h)	Total break time		milli seconds	
(i)	Operating mechanism type (Normal)			
	Operating mechanism type (Emergency)			
(j)	Minimum no. of auxiliary contacts			

Sr. No.	Description	Unit	Technical Particulars
(k)	Withstand test voltage		
	(i) One minute power frequency	kV (rms)	
	(ii) 1.2/50 μ sec impulse	kV (peak)	
(l)	Auxiliary control voltage (i) For closing / tripping coil		
	(ii) For spring charging motor		
	(iii) For space heaters and lighting		
	(iv) Permissible variation in operating voltage of closing & tripping coils		
(m)	Anti-pumping feature		
(n)	Latching requirement		
4.1.1.9	**Current Transformers**		
(a)	Type		
(b)	Class of insulation		
(c)	Rated current ratio and burden (i) Incomers and bus couplers		
	(ii) Outgoing feeders		
(d)	Accuracy class (i) Metering		
	(ii) Protection		
(e)	Short time 1 sec current rating	kA (rms)	
(f)	Dynamic rating	kA (peak)	
4.1.1.10	**Voltage Transformers**		
(a)	Type		
(b)	Rated Voltage (i) Primary	V	
	(ii) Secondary – S1	V	
(c)	Method of connection (i) Primary – P		
	(ii) Secondary – S1		
(d)	Application – S1		
(e)	Rated burden	VA	

Sr. No.	Description	Unit	Technical Particulars
(f)	Accuracy class		
(g)	Rated voltage factor (i) Continuous		
	(ii) Short time		
(h)	Insulation class		
4.1.1.11	**Meters**		
(a)	Make		
(b)	Accuracy Class		
	(i) Indicating Meters		
	(ii) Energy Meter		
4.1.1.12	**Protective Relays**		
(a)	Type		
(b)	Auxiliary supply		
4.1.1.13	Annunciations Provided as per Part 12 - Particular Electrical Requirement of Specification	Yes / No	
4.1.1.14	Whether Cubicle Components Provided as per Part 12 - Particular Electrical Requirement of Specification	Yes / No	
4.1.1.15	Auxiliary A.C. Supply Voltage & Frequency	V, Hz	

4.1.2 11 / 0.433kV Transformers

Sr. No.	Description	Unit	Technical Particulars
4.1.2.1	Make		
4.1.2.2	Type		
4.1.2.3	Applicable Standards		
4.1.2.4	Rated output	kVA	
4.1.2.5	Quantity required	Nos.	
4.1.2.6	Transformer location		
4.1.2.7	No load transformer ratio	kV/kV	

Sr. No.	Description	Unit	Technical Particulars	
4.1.2.8	Number of phases			
4.1.2.9	Rated frequency	Hz		
4.1.2.10	Impedance at all taps	%		
4.1.2.11	No load loss on principal tap	W		
4.1.2.12	Load loss on principal tap and rated kVA	W		
4.1.2.13	Dimensions	mm		
4.1.2.14	Weight	Kg		
4.1.2.15	Number of winding / materials of conductor/Insulation Class			
4.1.2.16	Method of connection			
(a)	HV winding			
(b)	LV winding			
4.1.2.17	Vector group			
4.1.2.18	LV Neutral			
4.1.2.19	Type of cooling			
4.1.2.20	Tap changer			
4.1.2.21	Tap range	%		
4.1.2.22	Tap step	%		
4.1.2. 23	Terminal connection			
(a)	HV terminals			
(b)	LV terminals			
4.1.2.24	Current Transformer			
(a)	On LV			
(b)	On LV Neutral			
4.1.2.25	LV Neutral earthing			
4.1.2.26	Insulation of Windings		H.V.	L.V.
(a)	One minute power frequency withstand voltage (dry and wet)	kV (r.m.s)		
(b)	1.2/50 microsecond full wave impulse withstand voltage	kV (peak)		
4.1.2.27	Insulation of bushings		H.V.	L.V. (Line and Neutral)
(a)	Rated Voltage of bushing	kV		

Sr. No.	Description	Unit	Technical Particulars	
(b)	One minute power frequency withstand voltage	kV (r.m.s)		
(c)	1.2/50 microsecond full wave impulse withstand voltage	kV (peak)		
(d)	Minimum creepage distance	mm		
4.1.2.28	Vacuum withstand capability of transformer main tank with bushings, radiations, fitting and accessories.			

4.1.3 415 V Metal Enclosed Switchgears (PCC) / MCC

Sr. No	Description	Unit	Technical Particulars
4.1.3.1	Make		
4.1.3.2	Type		
4.1.3.3	Applicable Standards		
4.1.3.4	**415 V Switchgear and Busbar Ratings**		
(a)	Rated voltage phase and frequency		
(b)	System Neutral Earthing		
(c)	Maximum system voltage	V	
(d)	One minute power frequency voltage		
	i) Power circuits	V	
	ii) Control circuits	V	
	iii) Aux. Circuits connected to Sec of CTS	V	
(e)	Continuous current rating of Busbars under site reference Ambient Temperature and type & material	Rating & Material	

Sr. No	Description		Unit	Technical Particulars
(f)	Busbar insulation			
(g)	Reference Ambient Temperature		^{o} C	
(h)	Maximum Temperature of Busbars, Droppers and Contacts at Continuous current rating under site ambient temperature		^{o} C	
(i)	Short Circuit current withstand for Busbars and droppers (i) Short time 1 sec		kA (rms)	
	(ii) Dynamic Rating		kA (peak)	
4.1.3.5	**Switchgear Constructional Requirement**			
(a)	Type of Construction			
(b)	Thickness of sheet steel (i) Frame, Frame enclosures, doors, covers and partitions		mm	
(c)	Degree of protection			
(d)	Colour finish shade			
(e)	Earthing bus	Material		
		Size	mm x mm	
(f)	Earthing conductor	Material		
		Size	mm x mm	
(g)	Minimum clearances in air of live parts (i) Phase to Phase		mm	
	(ii) Phase to Earth		mm	
(h)	Cable entry to cubicles			
4.1.3.6	**Instrumentation Transformers**			

Sr. No	Description	Unit	Technical Particulars
(a)	Current transformer		
	(i) Ratio		
	(ii) Burden	VA	
	(iii) Accuracy Class		
(b)	Voltage transformer		
	(i) Ratio		
	(ii) Burden	VA	
	(iii) Accuracy Class		
4.1.3.7	Auxiliary A.C. Supply		

4.1.4 415V Power Capacitor and Control Panel

Sr. No	Description	Unit	Technical Particulars
4.1.4.1	**General**		
(a)	Make		
(b)	Type		
(c)	Applicable Standards		
(d)	Rated Capacity	kVAR	
(e)	Rated Supply Voltage	V	
(f)	Rated frequency and phases		
(g)	Reference Ambient temperature	^{o} C	
(h)	Cable gland required		
(i)	Type of cable		
(j)	Size of cable		
(k)	Cable entry	Top/Bottom	
4.1.4.2	**Constructional Requirement**		

Sr. No	Description		Unit	Technical Particulars
(a)	Thickness of sheet steel i) Frame, Frame enclosures, doors covers and partition		mm	
(b)	Degree of protection			
(c)	Colour finish shade		Interior Exterior	
(d)	Main busbars and size			
(e)	Maximum Temperature of Busbars, Droppers and Contacts at Continuous current rating under site ambient temperature		^{o} C	
(f)	Earthing bus	Material		
		Size	mm x mm	
(g)	Earthing conductor	Material		
		Size	mm x mm	
4.1.4.3	**Design Requirement**			
(a)	Insulation level		kV (rms)	
(b)	Capacitor bank connection			
(c)	Short circuit withstand for busbars i) Short time (1 sec)		kA (rms)	
	ii) Dynamic		kA (peak)	
(d)	Type of switching			
(e)	Switching steps			
(f)	Switch and Rating of contactor			
(g)	Incomer MCCB current rating			
(h)	O/L capacity of capacitors			

Sr. No	Description	Unit	Technical Particulars
(i)	O/V capacity of capacitors		
(j)	Protections		

4.1.5 Diesel Standby Generator Set

Sr. No.	Description	Unit	Technical Particulars
4.1.5.1	**General**		
(a)	Set Manufacturer		
(b)	Quantity & Type	Nos	
(c)	Applicable Standard		
(d)	Rating	kVA	
(e)	Method of starting		
(f)	No. Of Phases, Rated Voltage, Frequency, PF and Speed		
(g)	Overload capacity		
(h)	Provision of Acoustic enclosure		
(i)	Provision of AMF Control Panel for all the DG Sets	Yes/ No	
4.1.5.2	**Alternator**		
(a)	Manufacturer		
(b)	Type		
(c)	Applicable Standard		
(d)	Rating	kVA	
(e)	Voltage	V	
(f)	Number of phases		
(g)	Frequency	Hz	
(h)	Power Factor		
(i)	Rated Current	A	
(j)	Overload Capacity		
(k)	Class of Insulation		
(l)	Degree of protection		
(m)	Winding Connection		
(n)	Short circuit current		

Sr. No.	Description	Unit	Technical Particulars
(o)	Type of rotor bearings		
(q)	Provision of temperature sensors in stator windings		
(r)	**Exciter**		
(i)	Make		
(ii)	Type		
(iii)	Applicable Standard		
(s)	**AVR**		
(i)	Make		
(ii)	Type		
(iii)	Applicable Standard		
(t)	**Voltage regulation**		
(u)	**Outgoing Cable**		
(i)	Make		
(ii)	Type		
(iii)	Applicable Standard		
(iv)	Size		
(v)	Winding material		
(w)	Rating of biggest motor which can be started on DOL		
(x)	Details of protection		
(y)	Efficiency		
4.1.5.3	**Diesel Engine**		
(a)	Manufacturer		
(b)	Type		
(c)	Applicable Standard		
(d)	Rating	HP / kW	
(e)	Speed	rpm	
(f)	Number of Cylinders		
(g)	Number of Strokes		
(h)	Type of Starting		
(i)	Duty		
(j)	Overload Capacity		
(k)	Radiator		

Sr. No.	Description	Unit	Technical Particulars
(i)	Make		
(ii)	Type		
(iii)	Fan power	kW	
(iv)	Cooling air flow		
(l)	**Exhaust system**		
(i)	Type of Silencer		
(ii)	Exhaust temperature gauge range		
(m)	**Governor**		
(i)	Make		
(ii)	Type		
(iii)	Applicable Standard		
(iv)	Class of governor		
(n)	**Cooling Water System**		
(i)	Water temperature		
(ii)	Water Pressure		
(iii)	System Capacity		
(iv)	Provision of High water temperature and low water level switches		
(o)	**Lubricating oil system**		
(i)	Grade of Oil		
(ii)	Oil Pressure		
(iii)	Oil temperature		
(iv)	Sump Capacity		
(v)	Oil Consumption per 100 hours		
(vi)	Recommended time period of Oil Change		
(p)	**Fuel**		
(i)	Fuel Specification		
(ii)	Fuel Consumption at rated Capacity		
(q)	**Day oil tank**		
(i)	Capacity	Litres	
(ii)	Provision of Level Gauge		
(r)	Starting system		

Sr. No.	Description	Unit	Technical Particulars
(s)	Type of cooling		
(t)	Exhaust system		
4.1.5.4	AMF Control Panel		
(i)	Make		
(ii)	Type		
(iii)	Applicable Standard		
(iv)	Constructional Features		
(a)	Thickness of sheet steel Frame, Frame enclosures, doors covers and partition	mm	
(b)	Colour finish shade - Interior		
(c)	Colour finish shade - Exterior		
(d)	Degree of Protection		
(v)	AMF Features Provided as per Technical Specification	Yes/No	
4.1.5.5	Protections, Alarm, Indications & Control whether provided as per Specification	Yes/No	
4.1.5.6	Acoustic Enclosure		
(i)	Make		
(ii)	Type		
(iii)	Applicable Standard		
(iv)	Constructional Features		
(a)	Thickness of sheet steel Frame, Frame enclosures, doors covers.	mm	
(b)	Degree of Protection		
(c)	Acoustic material		
(iv)	Sound level at 1m distance		
(v)	Whether certified to meet emission norms	Yes/No	
4.1.5.7	Battery		

Sr. No.	Description	Unit	Technical Particulars
(i)	Make		
(ii)	Type		
(iii)	Applicable Standard		
(iv)	Voltage		
(v)	Capacity at 10 hours rate		
(vi)	Number of successive starting permissible		
4.1.5.8	Battery Charger		
(i)	Make		
(ii)	Type		
(iii)	Applicable Standard		
(iv)	AC Input to Charger		
(v)	DC Output of Charger		

4.1.6 Variable Frequency Drives

Sr. No.	Description	Unit	Technical Particulars
4.1.6.1	**General**		
(a)	Make		
(b)	Type		
(c)	Applicable Standard		
(d)	Drive Application		
(e)	Quantity	No	
(f)	Type of converters		
(g)	Inverter capacity at specified pf		
(h)	Rated Current	A	
(i)	Load power factor		
(j)	Max. continuous current	A	
(k)	Rated voltage with number of phases	V	
(l)	Rated frequency	Hz	

Sr. No.	Description	Unit	Technical Particulars
(m)	Converter Bridge		
(n)	Single Quadrant/Two quadrant/ Four Quadrant		
(o)	Type of Duty		
(p)	Design Ambient Temperature	^{0}C	
4.1.6.2	Control Characteristics		
(a)	Speed Control		
(b)	Rated speed	RPM	
(c)	Speed ratio		
(d)	Constant torque/constant power		
(e)	Speed accuracy		
(f)	Closed loop/open loop		
(g)	Accel. / Deccel. time		
(h)	Possibility of Remote Operation	Yes / No	
4.1.6.3	Overall Harmonic Limitation	%	
4.1.6.4	Braking		
(a)	Type of braking		
(b)	Braking Torque		
4.1.6.5	Miscellaneous		
(a)	Soft-start	Yes/No	
(b)	Flying restart	Yes/No	
(c)	Auto restart	Yes/No	
(d)	Kinetic Buffering	Yes/No	
4.1.6.6	Confirm whether following minimum Indications on Drive Panel are Provided	Yes/No	

Sr. No.	Description	Unit	Technical Particulars
(a)	Motor running		
(b)	Motor stopped / trip		
(c)	AC mains 'ON'		
(d)	System Ready to start		
(e)	VFD system fault		
4.1.6.7	Confirm whether Digital Display of following Minimum parameters on the Drive Panels:	Yes/No	
(a)	Input AC Voltage		
(b)	Input AC Frequency		
(c)	Input AC Current		
(d)	Output Voltage		
(e)	Output Current VFD/Bypass		
(f)	Output Frequency		
(g)	Motor speed		
(h)	Whether Necessary transducers provided for indicating motor speed & current in PLC/DCS.	Yes/No	

4.1.7 Battery

Sr. No.	Description	Unit	Technical Particulars
4.1.7.1	Make		
4.1.7.2	Type of battery		
4.1.7.3	Applicable Standards		
4.1.7.4	Number of battery banks required		

4.1.7.5	Ambient conditions	Min Temp & Max. Temp Deg C	
4.1.7.6	D.C. system voltage	V	
4.1.7.7	Ampere hour capacity of battery at 27 Deg. C at 5-hour rate to give final cell voltage of 1.16 volts/cell	Ah	
4.1.7.8	Momentary load/duration	A	
4.1.7.9	Emergency load/duration	A	
4.1.7.10	Continuous load/duration	A	
4.1.7.11	Nominal voltage	V	
4.1.7.12	Cell voltage - initial/final	V	
4.1.7.13	Discharge rate	Hours	
4.1.7.14	Number of cells per bank required to give rated voltage	Nos.	
4.1.17.15	Number of spare cells per bank	Nos.	
4.1.17.16	Overall dimensions		
4.1.7.16.1	Each Cell (L x W x H)	mm	
4.1.7.16.2	Complete battery in the rack	mm	
4.1.7.17	Mounting arrangement		
4.1.7.18	Charging method		

4.1.8 Battery Charger

Sr. No.	Description	Unit	Technical Particulars
4.1.8.1	**General**		
(a)	Make		
(b)	Applicable Standards		
(c)	Type		

Sr. No.	Description		Unit	Technical Particulars
(d)	Number required		Nos.	
(e)	Rated Output voltage (DC)		V	
(f)	Rated Output		kW	
(g)	DC System Earthing			
(h)	Voltage regulation from no load to rated load		%	
(i)	AC ripple in DC output voltage at rated continuous load		%	
(j)	Type of rectifier			
(k)	Transformer			
(l)	Ambient Design Temperature		Deg. C	
(m)	Busbar material & size		-	
(n)	Overall dimensions		mm	
4.1.8.2	**Battery Details**			
(a)	Float/Trickle charging current of battery		mA	
(b)	Boost Charging Current of Battery (Maximum)		A	
(c)	Boost Charging Voltage of Battery (maximum)		V	
(d)	Maximum Time for Boost charging of Battery		hr	
(e)	Battery capacity & no. of cells		Ah	
			Nos.	
4.1.8.3	**AC System Data**			
(a)	Supply	Voltage	V	
		Phase		
(b)	(i) Variation in supply Voltage		%	
	(ii) Variation in supply frequency		%	
(c)	Short Circuit level		kA	
(d)	Type of earthing			

Sr. No.	Description		Unit	Technical Particulars
4.1.8.4	**Performance**			
(a)	DC voltage setting adjustment for float charger			
(b)	Voltage stabilisation for constant voltage regulator			
(c)	Maximum permissible variation in DC voltage (no load to full load)			
(d)	D.C. voltage setting adjustment for boost charging			
(e)	D.C. current adjustment for boost Charging			
(f)	Current stabilisation for constant current regulator for boost charger			
(g)	Minimum permissible power factor to rated continuous load			
(h)	Permissible ripple content at rated continuous load			
(i)	Relay for auto changeover from Float to boost mode to be provided (in case of float-cum-boost charger)			
4.1.8.5	**Constructional Features**			
(a)	Thickness of sheet steel Frame, Frame enclosures, doors, covers and partition		mm	
(b)	Degree of protection			
(c)	Colour finish shade			
(d)	Busbar material & size			
(e)	Earthing bus	Material		
		Size	mm x mm	
(f)	Earthing conductor	Material		
		Size	mm x mm	
(g)	Cable entry			
(h)	Cable Sizes			

Sr. No.	Description	Unit	Technical Particulars
	(i) Battery	sq.mm	
	(ii) DC output	sq.mm	
	(iii) AC input	sq.mm	

4.1.9 DC Distribution Board

Sr. No.	Description		Unit	Technical Particulars
4.1.9.1	**General**			
(a)	Make			
(b)	Applicable standards			
(c)	DC System voltage (Nominal)		V	
4.1.9.2	DC System Earthing			
4.1.9.3	Ambient Design Temperature		Deg. C	
4.1.9.4	Bus bar material, rating and size			
4.1.9.5	**DC Bus Load**			
(a)	Total continuous DC load		A	
(b)	Short time loads (Additional to continuous loads)			
	(i) DC lights/Facia lamps		A	
	(ii) Starting current and duration of Largest Connected DC Motor		A	
4.1.9.6	**Constructional Features**			
(a)	Thickness of sheet steel Frame, Frame enclosures, doors, covers and partition		mm	
(b)	Degree of protection			
(c)	Colour finish shade			
(d)	Earthing bus	Material		
		Size	mm x mm	

(e)	Earthing conductor	Material		
		Size	mm x mm	
(f)	Cable entry			
(g)	Cable Sizes (i) DC Input from Battery		sq.mm	
	(ii) DC output to Load		sq.mm	

4.1.10 Non-Segregated Bus Duct

Sr. No.	Description	Unit	Technical Particulars
4.1.10.1	Type of Bus Duct		
4.1.10.2	Type of Cooling		
4.1.10.3	Installation		
4.1.10.4	Nominal Service Voltage	V	
4.1.10.5	Rated Voltage Class	V	
4.1.10.6	Continuous Current Rating of Bus Ducts under Site Conditions	A	
4.1.10.7	One-minute Power Frequency Withstand Voltage	V	
4.1.10.8	Momentary Current Rating	kA	
4.1.10.9	Short Time Current Rating for one second - kA (RMS)	kA	
4.1.10.10	Maximum Temperature (Hot Spot) of Busbars at Rated Current	°C	
4.1.10.11	Maximum Temperature (Hot Spot) of Enclosure at Rated Current	°C	
4.1.10.12	Busbar Material		
4.1.10.13	Busbar Section		
4.1.10.14	Bus Enclosure Material		
4.1.10.15	Thickness of the Enclosure	mm	
4.1.10.16	Shape of Enclosure		
4.1.10.17	Phase Clearance (Minimum) Phase to Phase Phase to Earth	 mm mm	

Sr. No.	Description	Unit	Technical Particulars
4.1.10.18	Type of Joints between Adjacent Sections of Bus Conductor Welded/Bolted		

4.1.11 Cables

Sr. No.	Description	Unit	Technical Particulars
4.1.11.1	**11kV (UE) XLPE Insulated Power Cables**		
(a)	Make		
(b)	Type		
(c)	Applicable Standards		
(d)	Cable size selection whether done as per Specification	Yes /No	
(e)	Continuous current rating with cable laid in air/ground under specified ambient temperature	A	
(f)	Conductor material		
(g)	Conductor screening		
(h)	Insulation		
(i)	Screening on Insulation		
(j)	Identification of codes		
(k)	Inner sheath		
(l)	Filler material		
(m)	Armouring		
(n)	Outer sheath		
(o)	Overall diameter of cable	mm	
(p)	Recommended minimum bending radius	mm	
(q)	Standard length of cable on each drum	Mtr.	
4.1.11.2	**1100 V Grade XLPE Insulated Power Cables**		
(a)	Make		

Sr. No.	Description	Unit	Technical Particulars
(b)	Type		
(c)	Applicable Standards		
(d)	Cable size selection whether done as per Specification	Yes /No	
(e)	Conductor material		
(f)	Insulation		
(g)	Inner sheath		
(h)	Armouring		
(i)	Outer sheath		
(j)	Overall diameter of cable		
(k)	Recommended minimum bending radius	mm	
(l)	Standard length of cable on each drum	Mtr.	
4.1.11.3	**650/1100 V Grade PVC Insulated Control Cables**		
(a)	Make		
(b)	Type		
(c)	Applicable Standards		
(d)	Conductor material		
(e)	Insulation		
(f)	Inner sheath		
(g)	Armouring		
(h)	Outer sheath		
(i)	Standard length of cable on each drum	Mtr.	

4.1.12 Lighting Fixtures and Accessories

Sr. No.	Description	Unit	Technical Particulars
4.1.12.1	**General**		
(a)	Illumination levels at various premises whether considered as per	Yes /No	

Sr. No.	Description	Unit	Technical Particulars
	Specification		
(b)	Normal supply voltage, phase and frequency	AC	
		DC	
(c)	Variation in supply:		
	(i) Voltage (AC & DC)	%	
	(ii) Frequency	%	
	(iii) Combined voltage & frequency	%	
(d)	Design ambient air temperature	^{0}C	
4.1.12.2	Luminaire terminal suitable for		
(a)	Indoor area		
	(i) Conductor material		
	(ii) Cable size	Cores x mm^2	
(b)	Outdoor area		
	(i) Conductor material		
	(ii) Cable size	Cores x mm^2	
4.1.12.3	Luminaire earthing terminal suitable for		
	(i) Conductor material		
	(ii) Conductor size	SWG	
4.1.12.4	Luminaires		
(i)	LED Luminaires		
(a)	Make		
(b)	Type		
(c)	Rating		
(ii)	High / Medium / Low Bay LED Luminaires		
(a)	Make		

Sr. No.	Description	Unit	Technical Particulars
(b)	Type		
(c)	Rating		
(iii)	Flood Light LED Luminaires		
(a)	Make		
(b)	Type		
(c)	Rating		

4.1.13 Lighting System and Equipment

Sr. No.	Description	Unit	Technical Particulars
4.1.13.1	**System Particular**		
(a)	**Voltage**		
	(i) 3 Phase, 4 wire 50 Hz system		
	• Rated	V	
	• Maximum	V	
	• One minute withstand voltage		
	(ii) D.C. system		
	• Rated	V	
(b)	System short-circuit level		
	(i) At 415 V, A.C.	kA (rms)	
	(ii) At 110 V, D.C.	kA (D.C.)	
(c)	Reference ambient temperature	^{0} C	
4.1.13.2	**Distribution Board/Panels**		
(a)	Main, floor mounted distribution boards		
(i)	Main Lighting distribution board (A.C.)		

Sr. No.	Description	Unit	Technical Particulars
	• Make		
	• Type		
	• Degree of protection		
	• Bus bar material		
	• Bus bar current rating	A	
	• Short circuit current rating	kA	
	• Details of Incoming and Outgoing feeders		
	• Cable entry		
	• Location		
(ii)	Emergency lighting panel (D.C.)		
	• Make		
	• Type		
	• Degree of protection		
	• Bus bar material		
	• Bus bar current rating	A	
	• Short circuit current rating	kA	
	• Details of Incoming and Outgoing feeders		
	• Cable entry		
	• Location		
(iii)	Single phase DBs, wall/structure mounting		
	SLDB for indoor area		
	• Make		
	• Type		
	• Details of Incoming and Outgoing feeders		

Sr. No.	Description	Unit	Technical Particulars
	• Degree of Protection		
(iv)	SLDB for outdoor area		
	• Make		
	• Type		
	• Details of Incoming and Outgoing feeders		
	• Degree of Protection		
(v)	Paint Finish		
	(i) Colour shade:		
4.1.13.3 (a)	**Street Light Poles and Flood Light Poles** Street Light Pole		
	Type		
	Total Height:	Mtr.	
	Quantity:	Nos.	
(b)	Floodlight Light Pole		
	Type		
	Total Height:	Mtr.	
	Quantity:	Nos.	
	No. Of floodlights to be fixed per pole	Nos.	

4.1.14 Earthing and Lightning Protection System

Sr. No.	Description	Technical Particulars		
		Size	**Material**	**No. of Leads & Quantity**
4.1.14.1 (a)	**Main Earthing Grid** Buried in earth			
(b)	Buried in floor slabs in buildings			

Sr. No.	Description	Technical Particulars		
4.1.14.2	**Conductor Leads to Equipment** (above ground)			
(a)	Transformers			
(i)	Transformer neutral to bottom of tank			
(ii)	From bottom of tank to earth grid			
(iii)	Transformer tanks and radiator bank			
(b)	Diesel Generator Set			
(i)	DG Set neutral earthing			
(ii)	DG Set body earthing			
(c)	Fence posts and gates (Flex. braid)			
4.1.14.3	11kV Metal Enclosed Switchboard, 415Vswitchgear/ MCC.			
4.1.14.4	Motors			
(a)	415V Motors above 10 kW			
(b)	415V Motors up to 10 kW			
(c)	Fractional horse power motors			
4.1.14.5	**Other Items**			
(a)	Capacitor panel, Battery charger panel, DC distribution board, Main lighting D.B, Control panels and sub-lighting distribution boards			
(b)	Hand Rails			
(c)	Cable trays			
(d)	Tanks			
(e)	Junction boxes			
(f)	Lighting fixtures, receptacles, lighting conduits			
(g)	Push button stations, limit			

Sr. No.	Description	Technical Particulars		
	switches			
4.1.14.6	**Crane rail**			
4.1.14.7	Street lighting, flood lighting poles and junctions boxes			
4.1.14.8	Metallic non-current carrying structures			
4.1.14.9	**Lightning Conductors**			
(a)	Lightning protection down comers for building			
(b)	Lightning protection horizontal roof conductor for building			
4.1.14.10	**Electrodes**			
(a)	Pipe electrode			

4.1.15 Technical Particulars of Solar Panels

SL.NO.	DESCRIPTION	UNIT	TECHNICAL REQUIREMENT
4.1.15.1	**GENERAL**		
a	Application		
b	Cell type		
c	Type of design		
4.1.15.2	**ELECTRICAL DATA**		
a	Nominal minimum power @ STC	Wp	
b	Module Efficiency	%	
c	Operating temperature	^{0}C	
d	Maximum system voltage	V	
e	Power tolerance	W	
f	PID free solar cells	YES/ NO	
4.1.15.3	**MODULE TERMINAL BOX**		

a	IP		
b	Terminal cable		
c	Terminal connector		
4.1.15.4	**BYPASS DIODE**		
a	Efficiency	%	
b	Voltage drop	V	
c	Operating temperature	^{0}C	
4.1.15.5	Glass thickness	mm	
4.1.15.6	Anti-reflective coating required	YES/ NO	
4.1.15.7	Transmittance value	%	
4.1.15.8	Performance Warranty		

End of Schedule - IV

TECHNICAL SCHEDULE V
OPERATING DETAILS

(To be completed by the Bidder)

A) Power Consumption for WwTPs, TSPS (Will be considered for Financial Bid Evaluation)

S.No	Item	Power Consumption	
		kWh/ Day	kWh/Month
A	**TSPS and WwTP**		
1	20 MLD WwTP at Channasandra with Reuse		

Notes:

The Bidder shall substantiate Total Energy Consumption figure of the Plant by submission of Detailed Daily and Monthly Specific Energy Consumption Calculation.

The following factors / assumptions shall be considered by the Bidder in arriving at the Monthly Energy Consumption figures:

1) Plant is operated at average flow for 24 hours in a day for the entire month.
2) The Bidder shall consider 24 hours operation for Continuous Service Equipment's based on process requirement to meet the guaranteed outlet parameters.
3) The Bidder shall consider appropriate efficiency factor in arriving at working load of each equipment.
4) Number of days in month shall be based on 365days / 12months.

B) Chemical Dosing

S.No	Item	Chlorine Dose (mg/L)		Alum Dose (mg/L)		Polymer dose (kg/ton of dry solids)
		Average	Peak	Average	Peak	
1	20 MLD WwTP at Channasandra with Reuse					

Note:

Any other chemical as needed shall be included by the Bidder in the list.

C) Quantities of Chemical Consumptions (Will be considered for Financial Bid Evaluation)

S.No	Item	Alum		Chlorine		Polyelectrolyte	
		Kg/Day	Kg/Year	Kg/Day	Kg/Year	Kg/Day	Kg/Year
1	20 MLD WwTP at Channasandra with Reuse						

Note:

Any other chemical as needed shall be included by the Bidder in the list.

TECHNICAL SCHEDULE VI
SCHEDULE OF SUB CONTRACTORS
(To be completed by the Bidder)

The Bidder shall enter in this Schedule a list of the sub-components and approximate value (in terms of percentage of Cost of Construction Works) of the construction work for which he proposes to use subcontractors, together with the names and addresses of the proposed subcontractors. The Bidder shall also enter a statement of similar works previously executed by the proposed subcontractors, including description, location and value of work, year completed, and name and address of the Employer/ Employer's Representative. The Contractor shall provide evidence from the Employer/ Engineer that the subcontractor has previous successful experience in carrying out the works of a similar nature as the Contract. Notwithstanding such information, the Bidder, if awarded the Contract, shall remain entirely and solely responsible for the satisfactory completion of the Works.

Elements of Work	**Approximate Value of Work (INR)**	**Name and Address of Sub Contractor**	**Statement of Similar Works Previously Executed (Within last 5 years)**

TECHNICAL SCHEDULE VII

QUALITY ASSURANCE & QUALITY CONTROL PLAN

The Bidder shall provide copies of the company's standard rules and regulations regarding quality assurance and quality control procedures for works in general and works of a similar nature.

The Bidder shall provide its proposed Quality Assurance and Quality Control Plan in detail so as to demonstrate the procedures and tests that will be used to ensure that the quality concerns and requirements as set forth in conditions of contract, Quality Assurance as given in Volume 2, Technical Specifications are satisfactorily met.

The proposed plan will describe but not limited to:

- The type, frequency and procedure of tests to be done on sites;
- Type, frequency and procedure of tests to be done in pipe manufacturing units at site, if applicable;
- Type, frequency and procedure of tests to be done at manufacturers' locations outside the sites;
- All parameters to be measured in these tests; permissible limits of such parameters; details of laboratories to be established at sites; details of testing equipments & machines and their calibration schedules
- Details of the Bidder's internal systems for assuring quality control at the manufacturers' works outside the sites;
- Details of qualifications and experience of the Quality Control professionals to be deployed for the entire project; and
- The systems of Quality Audit to be instituted for systematic and professional management as well as adherence with the highest standards of quality of all construction works.
- All the tests of samples taken from the site are proposed to be done through recognized test houses of international standards and number of samples and frequency of sampling of materials brought to the site and the products manufactured at site shall be as per I.S. Specifications. All such samples shall be taken in the presence of Employer's authorized representatives or the Engineer.

The Bidder shall provide separate descriptions of its proposed QA/QC plan during the construction phase, and the subsequent operations and maintenance phase.

This will be an initial QA/QC plan which will address to basic requirements of Quality control and Quality assurance of the works.

TECHNICAL SCHEDULE VIII
ENVIRONMENTAL MANAGEMENT PLAN
(To be completed by the Bidder)

The Bidder shall provide his proposed Environmental Management Plan in detail so as to demonstrate the procedures that will be used to ensure that the environmental concerns and requirements as set forth in Part 3 (Refer Section 3.25) and Part 18 are satisfactorily met.

The Environment Management Plan shall identify the potential environmental impacts from the various construction and operations and maintenance activities to be undertaken in the Contract and set out in detail the approach that will be adopted in mitigating these environmental impacts to ensure that the residual impacts are minor and confined to a short period.

While preparing the proposed Environmental Management Plan the Bidder shall consider but not be limited to the following:

- The Bidder shall pay attention to the methods of materials delivery, storage, usage and disposal; equipment usage; and site activities to ensure they have minimal impact on the environment,
- The Bidder shall propose only environmentally safe products and practices in performing his works, and
- The Bidder shall comply with all of the statutes regarding environmental effects.

The Bidder shall provide separate descriptions of its proposals for minimizing any adverse environmental impacts/effects during the construction phase and the subsequent operations and maintenance phase.

This will be an initial Environmental Management Plan (EMP) which will address all moderate and significant negative impacts of the construction and operation and maintenance activities to be performed in the contract.

TECHNICAL SCHEDULE IX

SAFETY PLAN

(To be completed by the Bidder)

The Bidder shall provide his proposed Safety Plan in detail so as to demonstrate compliance with the requirements set forth in Section 3.26 of Part 3- General Requirements are satisfactorily met.

The Safety Plan shall include a policy statement signed by the CEO or equivalent authority of the Organization declaring that Safety and loss prevention shall be given the highest practicable priority in all aspects of the Contract.

The Bidder shall describe his proposed Safety Plan which shall be developed to ensure zero fatal accidents and zero hazardous incidents/occurrences in all construction works, including descriptions of the company's standard policies and procedures regarding its site organization and procedures implementations, methods and frequency of conducting safety audits/inspection at the Site(s), record keeping and reporting includes compliance reports and monthly reporting, timely corrective action implementation for the issues, supervising and monitoring to sustain the established safety management system, conducting safety review meetings, providing safety training for its personnel as required for all major critical activities of the sites, issue and mandatory use of safety equipment and penalties for non-compliance to be adopted within contractor organizations, keeping the plant and equipment's well maintained and details of the qualifications and experience of the Bidder's proposed Accident Prevention Officer(s) to be deployed at the Site(s).

The Bidder shall provide separate descriptions of its proposed Safety Plan during the construction phase and the subsequent operations and maintenance phase.

This will be an initial Safety Plan which will address to the Health and Safety of the all persons entitled to be at Site(s) including the Employer's personnel.

TECHNICAL SCHEDULE X

FUNCTIONAL GUARANTEES OF THE PLANT

(To be completed by the Bidder)

1.0 General

This document sets out the functional guarantees required to be provided by the Bidder for assessing the performance of the Works. These guarantees shall be used by the Employer to evaluate Bidder's satisfactory performance during the Tests after Completion, and also throughout the Operation and Maintenance Period.

The Bidder shall complete the following sections and provide values for the electrical energy usage for the Works covered under the contract, based on the raw sewage flows and characteristics and effluent and sludge quality requirements as given in Volume 2 (Employer's Requirements).

2.0 Functional Guarantees

2.1. Effluent and Sludge Quality

The Bidder guarantees that the effluent and sludge quality requirements specified in Volume 2 will be fully and completely met, under either actual or simulated design raw sewage flows, loadings, and characteristics, as demonstrated by the Tests after Completion. The bidder further guarantees that the specified requirements will continue to be fully and completely met throughout the Operation and Maintenance Period.

2.2. Electrical Energy Usage

The Bidder guarantees that electrical energy usage of works will not exceed the values listed in the table below, as demonstrated by the Tests after Completion and throughout the Operation and Maintenance Period. The actual electrical energy usage shall be directly metered and compared to guaranteed numbers on a monthly basis.

S.No	Item	Guaranteed Power Consumption (kWh per Month) PC_D
A	**TSPS and WwTP**	
1	20 MLD WwTP at Channasandra with Reuse	

Note:

1) Electrical Load List shall be provided for entire plant for each location to arrive guaranteed power consumption, considering the minimum equipment requirements as per tender specifications.
2) In case the Bidder fails to consider any of the above said factors, the Employer has the sole authority to do necessary corrections and consider revised figures for NPV Calculation during Evaluation of the Bid.

2.3. Energy Consumption during Operation and Maintenance Period

Energy Consumption during Operation and Maintenance Period for works during operation and maintenance period shall be calculated as per the below formula. This formula shall be applied for arriving the guaranteed power consumption based on actual flow and actual inlet sewage characteristics.

Symbol Definitions:

The following symbol definitions shall apply for the subsequent clauses of this schedule

PC_D = Guaranteed power consumption under design conditions for complete works of plant, (kWh per day)

PC_A = Guaranteed not-to-exceed power usage under actual daily operating conditions for complete works of plant, (kWh per day)

Q_D = Design average influent sewage flow for plant (MLD)

Q_A = Daily actual metered influent sewage flow for plant (MLD)

B_D = Design average influent sewage BOD concentration of plant (mg/L)

B_A = Daily average of actual measured influent sewage BOD concentrations (mg/L)

N_D = Design average influent sewage TKN concentration of plant (mg/L)

N_A = Daily average of actual measured influent sewage TKN concentrations (mg/L)

T_D = Design average influent sewage TSS concentration of plant (mg/L)

T_A = Daily average of actual measured influent sewage TSS concentrations (mg/L)

a) **Energy Consumption for TSPS, WwTP with Reuse**

Guaranteed not-to-exceed power consumption under actual daily operating conditions shall be calculated as per formula below:

$PC_A = [\{PC_D\}*\{(0.42*Q_A/Q_D)+(0.24*B_A/B_D)+(0.24*T_A/T_D)+(0.1*N_A/N_D)\}]$

2.4. Energy Consumption during Operation and Maintenance Period

During operation and maintenance following table will be used for checking the guaranteed power consumption on actual monthly basis.

S.No	Location	Day 1	Day 2	.....	.....	Day 30	Day 31	Total ΣPC_A
A	**TSPS and WwTP**							
	20 MLD WwTP at Channasandra with Reuse							

Note:

1) Power consumption (PC_A) in a month during O&M period should be less than or equal to power consumption under design conditions (PC_D) of the month for all constructed facilities of the plant.

2.5. Solar Power Generation during Operation and Maintenance Period.

The guaranteed Solar Power generation from the Solar PV panels shall not be less than 4,50,000 kWh/Year (Average 37,500 kWh/Month). During the Operation and Maintenance period, if the installed solar panels fails to achieve the guaranteed solar power, then the following formula shall be applied to calculate the penalty on differed solar power generation.

Penalty Formula

If

A ≥ N x SA

Then No Penalty

Else Penalty

if

A < N x SA

Then

Penalty = [{(N x SA) – A} × R × RSF]

Where:

A = Actual Power Generation kWh / Month

N = Normalised Guaranteed Power Generation kWh / Month

N = G x 90%

G = Guaranteed Power Generation kWh / Month

R = Prevailing Power Rate INR per kWh

SA = Monthly Severity Score for Aging (SA = 1 - 0.07% × No of Months)

RSF = Relative Severity Factor

RSF = (0.5 × SW) + (0.5 × SM)

SW =	**Monthly Severity Score for Weather**	**Score**
	Full sun, 30 to 24 clear sunshine days per month	1.0
	Intermittent clouds, 23 to 15 clear sunshine days per month	0.7
	Monsoon/cloudy, 14 to 6 clear sunshine days per month	0.4
	Very poor irradiance, heavy rains, 5 to 0 clear sunshine days per month	0.1
SM =	**Monthly Severity Score for Improper Maintenance**	**Score**
	Panels cleaned biweekly, inverters/logs OK	0.1
	Occasional cleaning delays, minor inverter issues	0.4
	Cleaning skipped >4 weeks, multiple minor faults	0.7
	Severe neglect, visible soiling, inverter breakdown, alarms ignored	1.0

TECHNICAL SCHEDULE XI

STATEMENT OF DEVIATIONS FROM THE TECHNICAL SPECIFICATIONS

(To be completed by the Bidder)

Name of the Bidder

The Bidder shall describe all proposed deviations from the Specifications set out under Volume 2, Section 7, clause by clause, in this Schedule.

The Bidder shall note that the Specifications given in the Bid Document are the minimum acceptable, and that only standard that is better / higher than the ones referred to in the Bid Document will be acceptable. Acceptance of the Bid shall not be construed as approval by the Employer of any deviations from the Technical Specifications. All details will be subject to the approval of the Engineer during execution of the Contract.

Sub-Section Number	Title of Sub-section	Clause No.	Specification as per Bid Document	Deviation & Specifications Proposed with standard code reference	Reasons for Deviation

The Bidder hereby certifies that the above-mentioned deviations are the only deviations from Specifications set out under Volume 2, Section 7, and that he accepts all the remaining technical requirements of the Bid Document. Further, the bidder shall also accept that there is a no deviation from the treatment process and treatment units specified under Volume 2, Section 7 of the bidding document.